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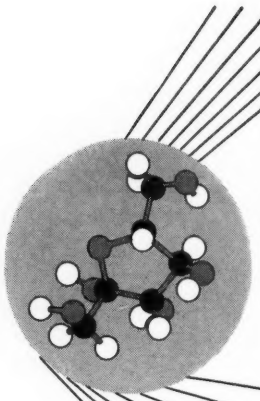

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SURGERY
GYNECOLOGY AND OBSTETRICS

VOLUME 96 FEBRUARY, 1953 NUMBER 2

THE RELATION BETWEEN THE PHYSIOLOGIC STIMULATORY MECHANISMS OF GASTRIC SECRETION AND THE INCIDENCE OF PEPTIC ULCERATION

An Experimental Study Employing a New Preparation

LESTER R. SAUVAGE, M.D., EVERETT J. SCHMITZ, M.D., EDWARD H. STORER, M.D., EDMUND A. KANAR, M.D., FRANKLIN R. SMITH, M.D., and HENRY N. HARKINS, M.D., F.A.C.S., Seattle, Washington

IT is significant that basic disagreements exist among the practices of leading surgeons concerning the management of those duodenal ulcer patients who require surgery. When one considers the tremendous volume of experimental and clinical work that has been done upon the duodenal ulcer problem, it is surprising that such differences still exist. It seems probable that if the pathogenesis and method of perpetuation of the pathologic duodenal process were better understood, there would result a more unified concept of the preferred method of surgical treatment of this common condition. We were motivated to devise and evaluate a new method of experimental peptic ulcer formation by the belief that the previously described methods of producing experimental peptic ulcer were not adequate to evaluate the relation between the physiologic stimulatory mechanisms of gastric secretion and the incidence of experimental peptic ulcer. We (1952) reported, on the basis of preliminary observations, that this experimental method of producing peptic ulceration seemed to be of value. In this report we wish to further detail the advantages and disadvantages of the method and to present the data obtained relative to the importance of the different phases of gastric secretion to the development of peptic ulceration with this preparation.

From the Department of Surgery, University of Washington, School of Medicine, Seattle, Washington.

This work was aided in part by grants from the Division of Research Grants and Fellowships, National Institutes of Health, Bethesda, Maryland, and Initiative 171 Research Funds provided by the State of Washington for research in the biological and medical sciences.

Dr. Sauvage is Damon Runyon Fellow, 1950–1952.

EXPERIMENTAL METHODS AND RESULTS

These studies were performed upon healthy adult mongrel dogs. The operative preparation employed for ulcer formation consists of a pouch of practically the entire parietal cell bearing portion of the stomach (all the stomach except the antrum and a narrow rim of cardia) which is drained by an isoperistaltic jejunal fistula into the second portion of the duodenum. With the dog under intravenous nembutal anesthesia, the pouch is formed by dividing the stomach 1 centimeter distal to the esophagogastric junction and again at the upper border of the antrum. The proximal end of the pouch is closed. A jejunal fistula 15 centimeters in length is procured by transecting the jejunum at 5 and 20 centimeters distal to the ligament of Treitz. Jejunal con-

tinuity is re-established by end-to-end anastomosis. The fistula is then made retrocolic and anastomosed end-to-end to the distal pouch and end-to-side to the duodenum. By excision of the antrum or by division of the gastric vagal fibers or both, the pouch may be made to function under varying degrees of stimulation via the natural stimulatory mechanisms. Alimentary continuity is re-established by cardioantrostomy when the antrum is preserved or by cardioduodenostomy when the antrum is excised. Dogs were considered as valid and thus suitable for tabulation only if they developed ulcer or lived more than 4 weeks after operation. Fifty-eight valid dogs comprise the series to be reported in this communication. The formation of this preparation involves an operation of considerable magnitude. In the first part of the series the operative mortality was high, but with experience the mortality fell to around 10 per cent. The operative time averaged around 2½ hours when the antrum was left in continuity and about 3 hours when the antrum was removed. We found that careful hemostasis was much easier and associated with fewer complications than was the case when blood was administered to compensate for poor hemostasis. Postoperative care of these animals has not followed a set pattern. Frequently, the only special postoperative care has consisted of depot penicillin given intramuscularly once daily for 3 days. Water is given as desired along with small amounts of milk and soft food. By the fifth postoperative day the dog is usually on regular kennel rations.

In the early experiments we divided the esophagogastric junction, but, because of serious postoperative vomiting in surviving animals, we later divided the stomach a centimeter or two distal to the esophagogastric junction. Initially, an upper midline abdominal incision was employed, but the exposure obtained was often poor. With such exposure, the procedure was difficult and carried a high mortality. Subsequently, we used a transthoracic transdiaphragmatic approach and obtained excellent exposure. However, vomiting was a troublesome postoperative complication in these experiments. Apparently, the division of the diaphragmatic fibers about the lower esophagus destroyed at least a part of the normal esophagogastric sphincteric mechanism. By placing the dog partly on its side and making a left subcostal incision, the exposure shown in Figure 1 could be routinely obtained. By preserving a narrow rim of cardia (1 to 2 cm.) and not traumatizing the diaphragmatic attachments about the lower esophagus, postoperative vomiting could be largely prevented. The performance of a pyloromyotomy was also of benefit in those experiments in which the antrum was left in continuity.

The time required for the dogs to adjust to the small size of their food reservoir varied considerably. However, once they began to eat slowly, vomiting did not occur. Those dogs which did not succumb to ulcer complications maintained themselves in good nutritional status in most instances. Often they would nibble away at their food for 10 to 12 hours before finishing. The majority of these dogs had good appetites and would eat as much as normal dogs with intact stomachs. Their stools, though often semisolid, were quite normal in appearance. Diarrhea was an infrequent postoperative occurrence. The weights of the dogs were checked at weekly intervals. The per cent change in the weights of the dogs are listed in Figures 2, 5, 7, and 8. In a few experiments the weights of the dogs were not recorded at the time of operation. In these instances the operative weight was assumed to equal the first weight taken after operation (usually within a week) plus 1 or 2 kilograms depending on the size of the dog.

Both fistulous and pouch ulcers were observed, occasionally multiple and in some instances both types in the same animal. The jejunal ulcers typically occurred just distal to the gastrojejunostomy and varied in size from small discrete ulcers to large ulcerations extending nearly the entire length of the fistula. Death usually resulted from generalized peritonitis subsequent to ulcer perforation. These ulcers have been of an acute nature on the basis of gross pathologic examination when the animal survived only a few days and of a more chronic nature (Fig. 4) when the animal survived for longer periods.

Ten dogs living more than 4 weeks after operation died without ulcer. Seven of these

died from intestinal obstruction due to herniation of the small bowel behind the mesentery of the jejunal fistula. This complication occurred frequently when the jejunal fistula was placed in an antecolic position. This occurrence has led us routinely to place the fistula in a retrocolic position. The incidence of intestinal obstruction has been low since this change in the position of the fistula was made. Two dogs died of inanition, one of these after repeated bouts of intestinal obstruction. One dog died from complications of a retained sponge.

None of the dogs dying with or without ulcer have shown any evidence of esophagitis.

Several dogs were explored to determine whether ulceration of the jejunal fistula had occurred. Just prior to being anesthetized, the dogs were allowed to drink milk and at laparotomy milk was found in the pouches. However, food particles were seldom present in the pouches at the time of exploration. In several dogs the fistulas were excised and a nylon cannula placed in the pouch of each. The secretions of the pouch were then quantitatively collected. The free hydrochloric acid secretory response of the pouch to the following stimuli was determined: (1) eating, (2) 20 units of crystalline insulin administered intravenously, (3) 1 milligram of aqueous histamine administered subcutaneously, and (4) 30 milligrams of histamine in beeswax administered intramuscularly. These data are tabulated in Table I.

We observed the incidence of ulcer formation that developed with the pouches secreting under the influence of the different stimulatory mechanisms. Four different combinations were studied: cephalic, antral, and intestinal; antral and intestinal; cephalic and intestinal; and intestinal. The results obtained in these four groups will be considered individually.

Three phase (cephalic, antral, and intestinal) total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. In this three phase preparation the pouch is formed as previously described. As shown in Figure 2, the vagus innervation to the pouch is preserved, and the rim of cardia attached to the esophagus is anastomosed to the gastric antrum. The vagal fibers to the pouch are preserved by separating the neurovascular elements about the upper stomach from the cardia before dividing the stomach just distal to the esophagogastric junction.

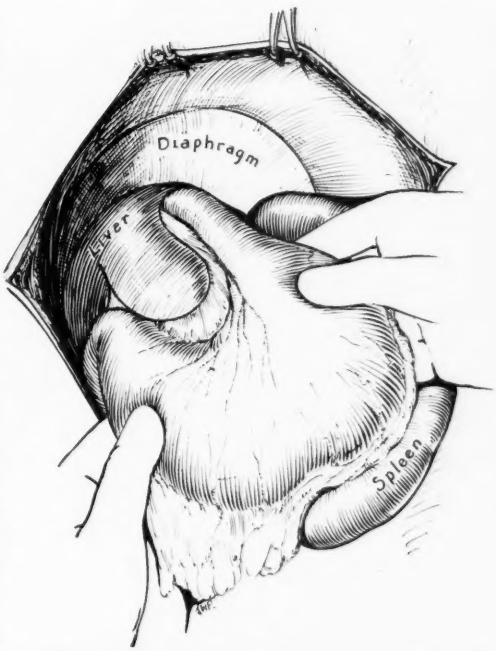
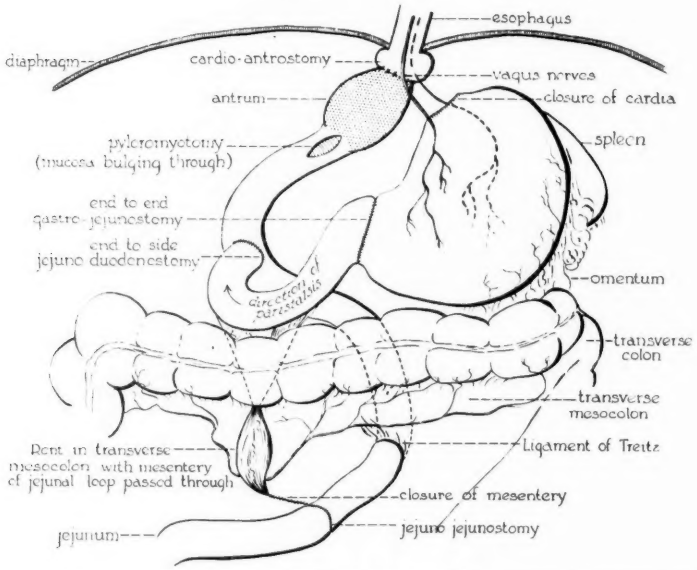


Fig. 1. This drawing illustrates the exposure of the stomach that may be routinely obtained by a left subcostal incision with the dog in the semilateral position. Retraction of the costal margin is facilitated by placing 2 towel clips through the edge of the costal margin and attaching them to a simple overhead pulley system which can be easily regulated.

As detailed in Figure 2, there were 18 dogs in this series. Eighteen or 100 per cent of these dogs developed ulcer with an average survival period of 40 days and an average weight loss of 20 per cent. Fifteen or 83 per cent of these dogs died with ulcer after an average survival period of 21 days, while 3 or 17 per cent of these dogs had an ulcer in their fistula at the time of fistula excision after an average survival period of 133 days. Figure 3 shows the necropsy specimen of a three phase dog dying on the 41st postoperative day from generalized peritonitis subsequent to perforation of a stomal ulcer. Figure 4 illustrates the histo-



		No.	Per cent of total	Average survival days	Average per cent weight change
Dogs dead* without ulcer		0	0	0	0
Dogs still living** without ulcer		0	0	0	0
Dogs with ulcer*** in excised fistula		3	17	133	23 ↓
Dogs dead with ulcer	Gastric	3	17	9	11 ↓
	Jejunal	9	50	25	21 ↓
	Gastric and jejunal	3	17	21	24 ↓
Total dogs		18	100	40	20 ↓
Total dogs dead with ulcer		15	83	21	20 ↓
Total dogs with ulcer		18	100	40	20 ↓

*Only includes dogs dying 4 weeks or more after operation.
**No evidence of ulcer found at exploration. Average survival days and per cent of weight change in these dogs refer to time from operation to exploration.
***Average survival days and per cent of weight change in these dogs refer to time from operation to fistula excision.

Fig. 2. A three phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. Each of the three phases of gastric secretion (vagal, antral, and intestinal) are operating upon the pouch. The fate, average survival days, and per cent of weight change of the 18 dogs in this series are shown. (N.B.: The taenia coli shown in this figure as well as in Figs. 5, 7, and 8 conform more to the human than to the canine type, but are so shown here diagrammatically.)

logic picture of the ulcers that were of a chronic nature.

The secretory responses of a three phase pouch were studied. These data are shown in Table I. This dog had a small chronic stomal ulcer in the jejunal fistula at the time of fistula excision 253 days after operation. The pouch gave a strongly positive response to insulin stimulation, secreted considerable quantities of free acid in response to eating, and large quantities after histamine stimulation.

The vagi were demonstrated to be anatomically intact to the pouch in all animals with three phase pouches at the time of necropsy.

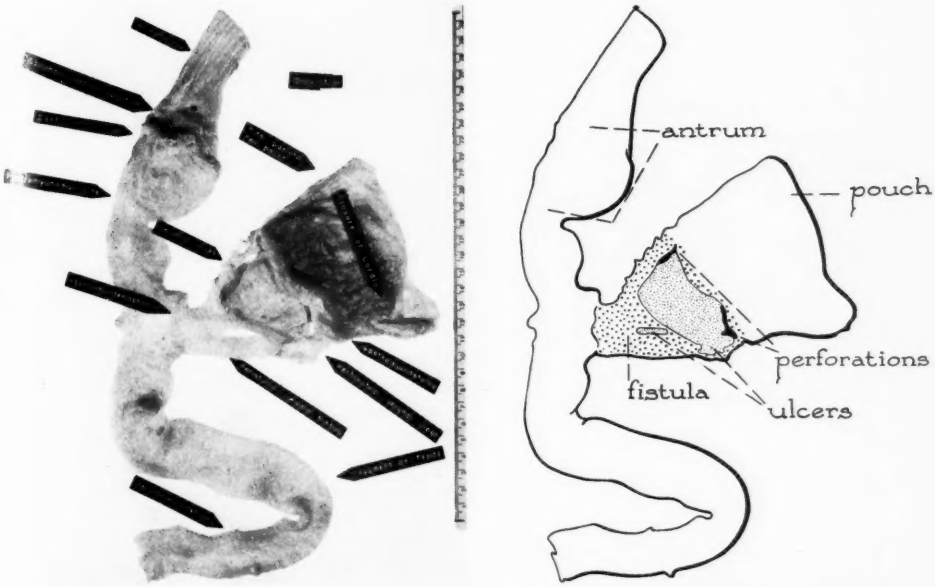


Fig. 3. The necropsy specimen shown in this illustration is a three phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The dog died on the 41st postoperative day from generalized peritonitis secondary to perforation of one of the jejunal ulcers. Two ulcers are present in the fistula. The first involves the entire proximal portion of the fistula. Its base, formed of omentum, is perforated in one area (appearing as two areas in the illustration). The base of the second ulcer, though showing as perforated in the photograph, was not perforated at the time of necropsy. This ulcer appeared grossly to be of an acute nature. Its base, being extremely thin, was torn in the handling of the specimen. Note the narrow rim of cardia attached to the esophagus and the complete absence of esophagitis. (In the diagram to the right, the ulcers appear as finely stippled areas, the perforations as black areas, and the jejunal fistula as a coarsely stippled area.)

Two phase hormonal (antral and intestinal) total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. In this two phase hormonal preparation the pouch is formed in the routine manner. The vagal fibers to the pouch are interrupted by dividing all the neurovascular components about the cardia. As shown in Figure 5, the rim of cardia attached to the esophagus is anastomosed to the gastric antrum.

As detailed in Figure 5, there were 10 dogs in this series. Ten or 100 per cent of these dogs developed ulcer with an average survival period of 59 days and an average weight loss of 24 per cent. Nine or 90 per cent of these dogs died with ulcer after an average survival period of 44 days, while 1 or 10 per cent of these dogs had an ulcer in its fistula at the time of fistula excision after a survival period of 198 days. Figure 6 shows the necropsy specimen of a two phase hormonal dog dying on the 41st postoperative day from generalized peritonitis subsequent to perforation of a stomal ulcer.

Cephalic-intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. In this preparation the pouch is formed in the usual manner. The vagal fibers to the pouch are preserved as in the case of the three phase preparation. As shown in Figure 8, the antrum is excised and the rim of cardia attached to the esophagus is anastomosed end-to-end to the first portion of the duodenum.

As detailed in Figure 7, there were 9 dogs in this series. Four or 45 per cent of these dogs developed ulcer with an average survival period of 76 days and an average weight loss of 24 per cent. In none of these dogs was there gross evidence of residual antral mucosa at

TABLE I.—SECRETORY RESPONSES OF CERTAIN TOTAL PARIETAL CELL POUCHES

Type of pouch	No. of dogs	Insulin test	Average mEq. of free HCl acid secreted		
			In 24 hours in response to routine feeding	In 1 hour in response to 1 mgm. of aqueous histamine subcutaneously	In 24 hours in response to routine feeding and 30 mgm. of histamine in beeswax intramuscularly
3 phase (cephalic, antral, and intestinal)	1	Positive	67	6	206
2 phase (cephalic and intestinal)	4	Weakly positive	14	8	135
1 phase (intestinal)	4	Negative	2	5	132

necropsy. One or 11 per cent of the dogs died of intestinal obstruction without ulcer after a survival period of 106 days and a weight loss of 8 per cent. Four or 45 per cent of the dogs were still living without ulcer when sacrificed after an average survival period of 202 days and an average weight loss of 1 per cent.

The fistulas were removed from 5 dogs at exploration, and the pouches cannulated. The secretory responses of 4 (3 without ulcer, 1 with ulcer) of these pouches were studied. These data are listed in Table I. All 4 pouches gave weakly positive insulin tests, secreted moderately in response to eating, and secreted large quantities of free acid in response to histamine stimulation. These 4 dogs died or were sacrificed at the completion of the secretory studies. The vagi were demonstrated to be anatomically intact to the pouch at necropsy in each of these 4 instances. Also, the vagi were found to be intact to the pouch in each of the other 5 cephalic-intestinal dogs at time of necropsy.

Intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The pouch is formed in this preparation in the same manner as in the other types. As shown in Figure 8, the vagal fibers to the pouch are interrupted as in the antral-intestinal phase pouch, and the antrum is excised with re-establishment of alimentary continuity as in the cephalic-intestinal phase pouch.

As detailed in Figure 8, there were 21 dogs in this series. One or 5 per cent of the dogs developed ulcer with a survival period of 33 days and a weight loss of 21 per cent. The necropsy specimen of this dog is shown in Figure 9. Nine or 43 per cent of the dogs died without ulcer after an average survival period of 70 days and an average weight loss of 28 per cent. Eleven or 52 per cent of the dogs were still living without ulcer after an average survival period of 176 days and an average weight loss of 3 per cent at which time the fistula was excised in 5 of the dogs. The absence of ulceration was ascertained by exploring the dogs and examining both the fistula and the pouch. In none were there signs to suggest ulceration either of the fistula or of the pouch. The fistula was left *in situ* in 6 of the dogs. These animals are being kept for longer term observation. At present these 6 dogs have survived an average of 383 days since operation (375 to 398 days) and have lost an average of 21 per cent of their preoperative weight (0 to 32 per cent). It is only fair to point out that these animals have not been fed as carefully as previously during the past 6 months. In each of the other 5 dogs that were explored, the fistula was excised and a cannula placed in the pouch. The secretory responses of 4 of these pouches were studied. These data are listed in Table I. All 4 pouches gave negative insulin tests, secreted minimally in response to eating, but secreted large quantities of free acid after histamine stimulation.

DISCUSSION

The words of the immortal Claude Bernard regarding scientific medicine would seem to include the problem of peptic ulcer when he said, "I consider hospitals only as the entrance to scientific medicine; they are the first field of observation which a physician enters; but the true sanctuary of medical science is a laboratory; only there can he seek explanations of life in the normal and pathological states by means of experimental analysis." Illuminating data can be obtained from the experimental animal which cannot be obtained from man. These data provide the basis for the rational formulation of the principles of patient therapy and guide their application in

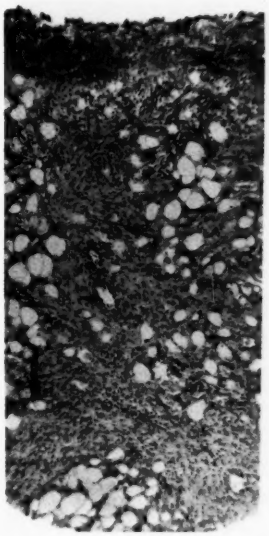
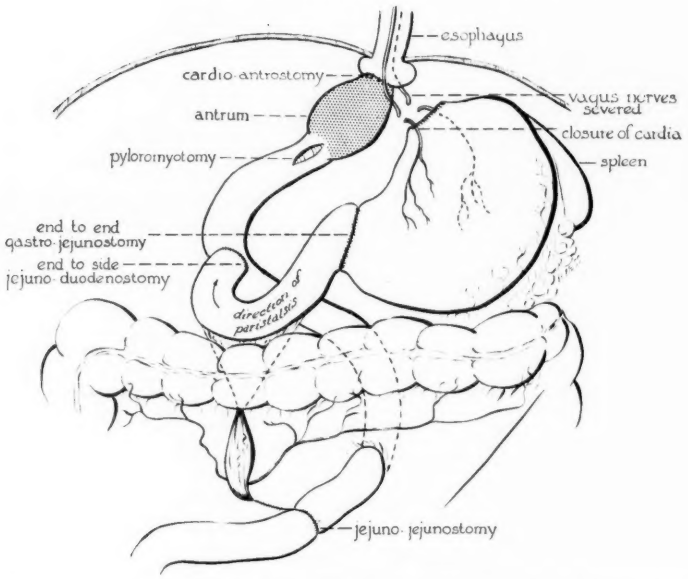


Fig. 4. The photomicrographs shown were taken of an ulcer present in the jejunal fistula of a three phase pouch preparation. The fistula was excised on the 63rd postoperative day. The upper photomicrograph was made at × 2.5 and the lower at × 50. The lower photomicrograph, taken in the area of the ulcer beneath which it is situated, shows the surface to be necrotic and the wall to be composed of fibrous tissue in which many fat cells are present. Omentum formed the base of the ulcer in this case.

practice. Any treatment of patients is an experiment of the highest order which ideally is confirmed in the experimental laboratory before being given careful clinical trial. The progress of medicine is assured by the use of this investigative sequence. It would seem of value to consider: (1) a listing of factors that might be responsible for the results obtained with the method of producing experimental peptic ulcer described in this report, (2) a comparison of the advantages and disadvantages of this method with those of certain other methods, and (3) a consideration of the possible significance of the findings obtained with this method as applied to the therapy of patients with duodenal ulcer. These topics will be considered in order.

It is accepted that gastric secretions can digest living tissues. Abundant evidence indicates that peptic ulceration results when the acid-peptic activity of the gastric juice overcomes the defense mechanisms of the tissue bathed by the gastric juice. This may result on the one hand from an increased secretion of potent gastric juice and on the other hand from a decrease in the defense mechanism of the tissue bathed by the gastric juice or by a combination of the two factors. It seems certain that a decreased defense mechanism contributes to the development of ulceration in the jejunal fistula with the method described in this report. The 15 centimeter isoperistaltic jejunal fistula interposed between the pouch and the duodenum acts at least par-



		No.	Per cent of total	Average survival days	Average per cent weight change
Dogs dead* without ulcer		0	0	0	0
Dogs still living** without ulcer		0	0	0	0
Dogs with ulcer*** in excised fistula		1	10	198	2 ↓
Dogs dead with ulcer	Gastric	1	10	2	5 ↓
	Jejunal	8	80	49	29 ↓
	Gastric and jejunal	0	0	0	0
Total dogs		10	100	59	24 ↓
Total dogs dead with ulcer		9	90	44	26 ↓
Total dogs with ulcer		10	100	59	24 ↓

*Only includes dogs dying 4 weeks or more after operation.
**No evidence of ulcer found at exploration. Average survival days and per cent of weight change in these dogs refer to time from operation to exploration.
***Average survival days and per cent of weight change in these dogs refer to time from operation to fistula excision.

Fig. 5. An antral-intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The neurogenic phase of gastric secretion has been removed by vagus nerve transections. The fate, average survival days, and per cent of weight change of the 10 dogs in this series are shown.

tially to prevent the protective alkaline hepatic, pancreatic, and duodenal juices from counteracting the corrosive action of the acid-peptic secretions of the pouch upon the proximal fistula.

Because of the small size of their food reservoir, these dogs eat small amounts frequently over a period of several hours; possibly the result is an increase in both the antral and vagal phases of gastric secretion. The practically constant presence of food on the antrum would tend to increase the action of that phase, while the frequent act of eating would tend to increase the vagal phase. As shown in Table II, the 100 per cent incidence of ulcer (18 of 18) developing in dogs with three phase

pouches would seem to support this thesis. The 100 per cent incidence of ulcer (10 of 10) developing in dogs with antral-intestinal phase pouches and the 5 per cent incidence of ulcer (1 of 21) in dogs with intestinal phase pouches indicate that in these dogs the antral phase is powerful and the intestinal phase weak. As shown in Table I, the weakness of the intestinal phase is attested to by the very low 24 hour free hydrochloric acid output in response to eating (average secretion of 2 mEq.) of the 4 one phase dogs that were studied. The 45 per cent incidence of ulcer formation (4 of 9) in the cephalic-intestinal phase dogs suggests an active role by the vagus, though less important than that of the antrum, in the genesis of ulcer by this experimental preparation. The average 24 hour output of free hydrochloric acid in response to eating (Table I) by 4 cephalic-intestinal phase dogs was only 14 milliequivalents. However, only 1 of these dogs had developed an ulcer in his fistula (average secretion in response to eating of this dog was 17 mEq. per 24 hour period). It could be that the other dogs developing ulcers in this series might have secreted considerably more than the average of 14 milliequivalents of free hydrochloric acid produced per 24 hours by the dogs that were studied.

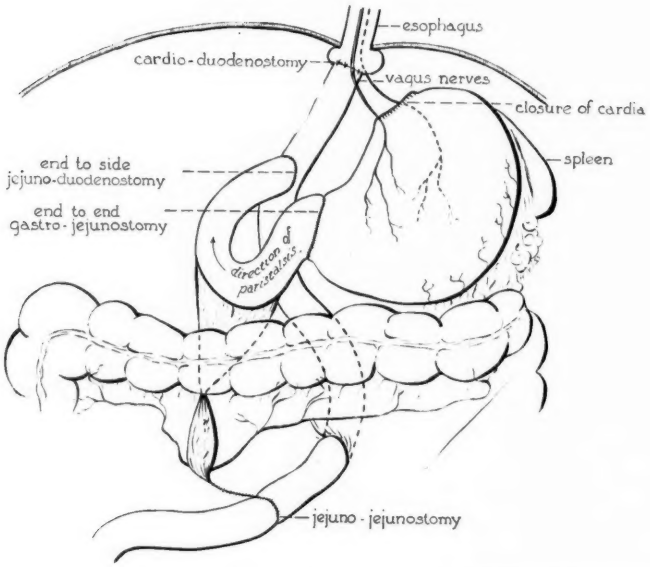
The work of Uvnäs (1942), Glass and Wolf (1950), Lim and Mozer (1951), and Noring (1951) suggests that the vagally innervated gastric antrum plays a positive role in the cephalic phase of gastric secretion. It may be that vagal excitation in addition to directly stimulating the parietal cells may also stimulate them indirectly by causing a release of gastrin by the antral mucosa. If such a hypothesis be correct, it would partially explain the intermediate incidence (Table II) of ulceration occurring with the cephalic-intestinal phase pouch preparation. In addition, the regurgitation of fluids up the fistula into the pouch would probably be important in the cephalic-intestinal phase pouch. Since these fluids would most likely gain access to the fistula during the time when acid was being most actively secreted in response to vagal stimulation, they would decrease the ulcer potential of the pouch secretions both by neutralization and dilution. This factor of regurgitation probably plays a minor role in neutralizing the acid secreted in response to antral and intestinal phase stimulation as such secretion is not significant in the first hour after eating. This secretion then increases in amount and continues for several hours. The fluids that regurgitate into the fistula and pouch immediately following eating probably return to the duodenum as its contents begin to be carried distally. The sustained acid secretion of the antral phase then bathes the fistula relatively uninhibited by neutralization from regurgitated fluids.

Fig. 6. The necropsy specimen shown is an antral-intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The dog died on the 41st operative day from generalized peritonitis secondary to perforation of the jejunal ulcer. Note the narrow rim of cardia attached to the esophagus and the complete absence of esophagitis.

The minimal response of the cephalic-intestinal phase pouches (Table I) to intravenous

TABLE II.—INCIDENCE OF PEPTIC ULCERATION IN DOGS WITH A TOTAL PARIETAL CELL POUCH DRAINED BY A PERISTALTIC JEJUNAL FISTULA INTO THE SECOND PORTION OF THE DUODENUM

	Dogs developing ulcer, per cent
3 phase (cephalic, antral, and intestinal)	100
Antral and intestinal	100
Cephalic and intestinal	45
Intestinal	5



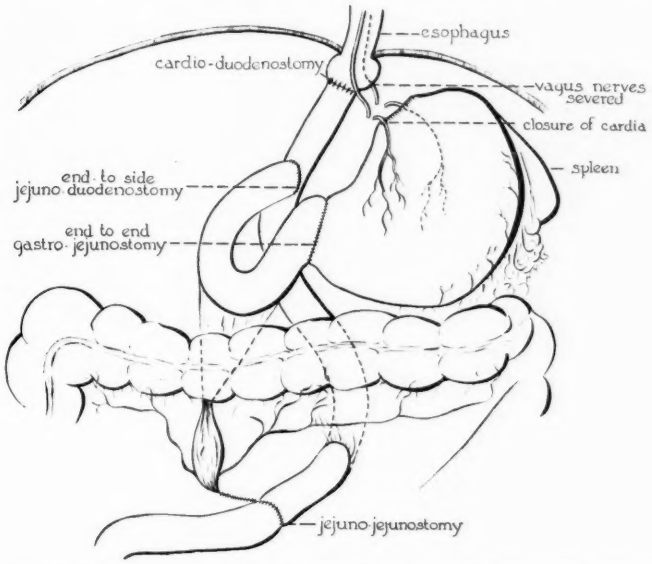
		No.	Per cent of total	Average survival days	Average per cent weight change
Dogs dead* without ulcer		1	11	106	8↓
Dogs still living** without ulcer		4	45	202	1↓
Dogs with ulcer*** in excised fistula		1	11	201	11↓
Dogs dead with ulcer	Gastric	0	0	0	0
	Jejunal	3	33	34	28↓
	Gastric and jejunal	0	0	0	0
Total dogs		9	100	147	12↓
Total dogs dead with ulcer		3	33	34	28↓
Total dogs with ulcer		4	45	76	24↓

*Only includes dogs dying 4 weeks or more after operation.
**No evidence of ulcer found at exploration. Average survival days and per cent of weight change in these dogs refer to time from operation to exploration.
***Average survival days and per cent of weight change in these dogs refer to time from operation to fistula excision.

Fig. 7. A cephalic-intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The gastric phase of gastric secretion has been removed by excision of the antrum. The fate, average survival days, and per cent of weight change of the 9 dogs in this series are shown.

insulin in each of 4 dogs is in accord with the observations on humans of Glass and Wolf (1950) and Glass, Mersheimer, and Svigals (1951). They noted in aspiration samples that removal of the gastric antrum abolished the free hydrochloric acid response of the stomach to intravenous insulin but did not interfere with the mucoprotein response of the stomach to intravenous insulin. Complete vagotomy abolished both the acid and mucoprotein responses of the stomach to intravenous insulin.

It has been observed by several including Oberhelman and Dragstedt (1948), Stein and Meyer (1948), and Antia and Ivy (1949) that vagotomy reduces the free hydrochloric acid output of the stomach to histamine stimula-



		No.	Per cent of total	Average survival days	Average per cent weight change
Dogs dead* without ulcer		9	43	70	28 ↓
Dogs still living** without ulcer		11	52	176	3 ↓
Dogs with ulcer*** in excised fistula		0	0	0	0
Dogs dead with ulcer	Gastric	1	5	33	21 ↓
	Jejunal	0	0	0	0
	Gastric and jejunal	0	0	0	0
Total dogs		21	100	124	15 ↓
Total dogs dead with ulcer		1	5	33	21 ↓
Total dogs with ulcer		1	5	33	21 ↓

*Only includes dogs dying 4 weeks or more after operation.
**No evidence of ulcer found at exploration. Average survival days and per cent of weight change in these dogs refer to time from operation to exploration.
***Average survival days and per cent of weight change in these dogs refer to time from operation to fistula excision.

Fig. 8. An intestinal phase total parietal cell pouch drained by a peristaltic jejunal fistula into the second portion of the duodenum. The neurogenic and gastric phases of gastric secretion have been removed by vagus nerve transections and excision of the antrum. The fate, average survival days, and per cent of weight change of the 21 dogs in this series are shown.

tion. Our data (Table I) indicate that the vagally denervated gastric pouch is still capable of tremendous free hydrochloric acid secretion in response to histamine stimulation, especially the beeswax preparation administered intramuscularly. This was particularly striking in a one phase pouch dog weighing 17 kilograms that secreted more than 300 milliequivalents of free hydrochloric acid over a 48 hour period in response to a single intramuscular injection of 30 milligrams of histamine in beeswax. Thus, it seems that long periods of inactivity by the parietal cells of the stomach do not cause them to lose their ability to secrete.

It is our opinion that the ulcer potential of the total parietal cell pouch drained by a peri-

staltic jejunal fistula is probably lower when the fistula is attached to the second portion of the duodenum than it would be if the fistula were drained into any other portion of the gastrointestinal tract. The possible reasons on which we base this opinion are that with the fistula attached to the second portion of the duodenum: (1) regurgitation of ingested fluids into the fistula is probably maximal; (2) regurgitation of the protective alkaline hepatic, pancreatic, and duodenal juices into the fistula is also probably maximal; and (3) the emptying of the acid gastric juice into the duodenum may act in some manner to depress further gastric acid secretion when the *p*H of the duodenum falls to 2.5 or lower. Suggestive, but certainly not conclusive, evidence regarding this presumed "duodenal inhibition" of acid secretion has been obtained by Day and Webster (1935), Pincus, Thomas, and Rehfuss (1942), and Storer, Oberhelman, Woodward, Smith, and Dragstedt (1952).

The development of gastric ulcers with the internally drained total parietal cell pouch preparation is of interest in view of the known high resistance of the mucosa of the stomach to acid-peptic digestion. Matthews and Dragstedt (1932) and Dragstedt, Woodward, Neal, Harper, and Storer (1950) have observed the development of peptic ulcers in vagally innervated isolated externally drained total gastric pouches. Stein, Grossman, and Ivy (1947) have observed ulcers to occur rapidly in closed partial gastric pouches of the Heidenhain type. Dragstedt, Oberhelman, and Smith (1951) observed the rapid development of ulcers in vagally denervated total gastric pouches after transplanting the antrum to the side of the duodenum or colon as a diverticulum. In several instances early in our experiment, the outlet of the pouch became obstructed either as a result of making an inadequate gastrojejunostomy stoma or as the result of kinking of the jejunal fistula. These dogs died within a few days from perforation of massive acute gastric ulcers. These dogs were not considered as valid preparations and are not included in the tabulations. However, a total of 8 dogs developed pouch ulcers in which no obstruction to the passage of fluid from the pouch could be demonstrated. Gastric ulcers occurred in 6 three phase pouches and were associated with jejunal ulcers in 3 instances. One gastric ulcer occurred in an antral-intestinal phase pouch and the other in an intestinal phase pouch (Fig. 9). It seems odd that an ulcer should have occurred in the one phase pouch. Grossly, all antral tissue appeared to have been removed, and all vagal fibers to the pouch had been divided. This was the only ulcer that developed in the one phase series of 21 dogs.

An acceptable method for the experimental production of peptic ulcer should satisfy the following criteria: (1) it must be a method by which ulcers can be produced (preferably rapidly) that will parallel as closely as possible peptic ulceration in man without requiring complicated postoperative care or artificial stimulation in test animals; (2) it must permit evaluation of therapeutic methods as to their effectiveness in preventing peptic ulcers in these preparations; and (3) when ulcer formation has been prevented (by some test procedure), the experimental animal must survive in good nutritional condition for prolonged periods of time. It would seem pertinent to examine some of the methods used for the production of experimental peptic ulcer in view of these criteria. The procedure of duodenal drainage, as described by Mann and Williamson (1923), has been used extensively to produce peptic ulcer in the dog. Animals subjected to this procedure usually succumb to ulcer complications after an average survival period of from 2 to 3 months. The chief disadvantage of the method is that in most instances the physical status of the dog rapidly deteriorates whether the dog develops an ulcer or not. Without special care, these dogs, even when protected from ulcer development, often die of inanition in about the same time as dogs dying with ulcer. This lack of survival in good nutritional condition of presumably protected animals makes interpretation uncertain regarding the protective effect observed against ulcer formation in this preparation by vagotomy as described by Harkins and Hooker (1947), and Enerson, Woodward, Tovee, Neal, Sibley, and Dragstedt (1950), by vagotomy plus antrum resection according to Storer, Woodward, and Dragstedt, 1950, and Oliver

(1951), and by banthine and atropine as reported by Harkins and Sauvage (1952).

The employment of histamine described by Varco, Code, Walpole, and Wangensteen (1941), a direct stimulant to the parietal cells, as a means of producing peptic ulceration does not allow a study of the physiologic stimulatory mechanisms of gastric secretion. Histamine is a valuable tool for studying many things but not for evaluating the role of the vagus nerves or of the gastric antrum either in gastric secretion or peptic ulceration. As seen in Table I, the administration of histamine even to the intestinal phase dogs resulted in the secretion of large quantities of free hydrochloric acid. It is most probable that had histamine in beeswax been administered to the different series of dogs while their pouches were draining internally, they would all have died with ulcer and all in about the same time. The report of Lillehei, Lewis, and Wangensteen (1950) in which it was shown that a gastric drainage procedure limits the effectiveness of vagotomy in dogs stimulated with histamine in beeswax would appear to apply only to stomachs stimulated constantly with histamine.

Dragstedt, Oberhelman, and Smith (1951) have shown that experimental peptic ulcers can be produced in the dog by transplanting the gastric antrum to the colon as a diverticulum placed in an isoperistaltic position. The distention of the antrum by fecal matter causes its hyperfunction which results in increased acid formation by the stomach. This method is of great interest and gives definitive proof that the gastric antrum is an endocrine organ. However, the method is limited as a means for studying the relation of the normal stimulatory mechanisms of gastric secretion to the development of peptic ulceration. Only when the antrum is in the colon as a diverticulum does ulceration occur. The method does, however, provide a ready means for studying peptic ulceration of antral origin.

No method of producing experimental peptic ulcer in laboratory animals can exactly reproduce the situation seen in the duodenal ulcer patient. The method that we are reporting most certainly does not. This method embodies the principle of ulcer formation in a

Fig. 9. The necropsy specimen shown here is the pouch and proximal fistula of the only intestinal phase total parietal cell pouch preparation that developed an ulcer. This dog died on the 33rd postoperative day from generalized peritonitis secondary to perforation of the gastric ulcer.

Meckel's diverticulum. In fact, the internally drained total parietal cell pouch may be considered as a Meckel's diverticulum of maximum size. Matthews and Dragstedt (1932), using partial gastric pouches, demonstrated the regular occurrence of peptic ulcer with this type of preparation. Of 19 dogs with partial gastric pouches of the Pavlov or Heidenhain type that were drained into the small intestine, 17 developed ulcer. Each of 6 dogs (100 per cent) with pouches drained into the ileum developed ulcer, while 11 of 13 dogs (85 per cent) with pouches drained into the jejunum developed ulcer. In the 17 dogs developing ulcer, the average time for operation to discovery of the ulcers was 67 days. No study was made of the relation of the stimulatory mechanisms of gastric secretion to the development of peptic ulcer with these partial pouch preparations. The use of internally drained total parietal cell pouches appears to be better suited for such a study than would partial parietal cell pouches. Although not perfect, the internally drained total parietal cell pouch preparation appears to have value in studying the relation of the physiologic stimulatory mechanisms of gastric secretion to the development of experimental peptic ulceration. A disadvantage of the method is

that it requires an operative procedure of considerable magnitude. Perhaps the chief advantage of the method is that animals not succumbing to ulcer complications survive in good nutritional status for prolonged periods with a minimum of special postoperative care. As shown in Figure 8, it appears highly significant that 11 one phase dogs (52 per cent of the series) were still living without ulcer an average of 176 days after operation at the time this tabulation was made. These dogs were in excellent physical condition and showed an average weight loss of only 3 per cent as compared to their preoperative weights. As mentioned previously, 5 of these dogs were sacrificed and 6 allowed to go on for long term studies, *vide supra*. Their average survival time to date, 176 days, is 300 per cent over that of the three phase dogs, all of which developed ulcer with an average survival period of 40 days. From such experimental data (Table II), it would seem that the combination of division of the vagal fibers to the pouch and excision of the gastric antrum is an efficient means of preventing the peptic ulceration produced by this preparation.

The object of the treatment of the duodenal ulcer patient who requires surgery is to eradicate the organic pathologic process, to prevent its recurrence, and to re-establish the physiologic processes in such manner as to allow the patient to lead a normal life. The simplest means whereby these goals can be achieved would appear to be the best. Gastroenterostomy can no longer be regarded as a satisfactory means of treating other than the occasional duodenal ulcer patient. Clark (1951) has reported that as high as 50 per cent of patients treated by posterior gastroenterostomy develop recurrent ulcer when followed over a 20 year period. Kanar, Schmitz, Sauvage, Storer, Diessner, and Harkins (1952) have shown that gastrojejunostomy of the main stomach causes a significant rise in acid secretion from Heidenhain pouches in dogs.

Simple vagotomy without a drainage procedure has largely been abandoned as a means of treating patients with duodenal ulceration because of the unpleasant side effects of gastric retention and the high incidence of recurrent ulceration. Storer, Schmitz, Sauvage, Kanar, Diessner, and Harkins (1952) have shown that vagotomy of the main stomach causes a profound rise in the acid secretion of Heidenhain pouches in dogs. It is postulated that this rise in acid secretion is due to the action of an increased quantity of circulating gastrin. It is thought that this increase occurs subsequent to a more rapid liberation of the hormone by the antrum as a consequence of the prolonged contact of the antral mucosa with the stomach contents as a result of the gastric stasis following complete vagotomy. These observations may help to explain the high incidence of recurrent ulceration that occurs following vagotomy without a drainage procedure. The results following vagotomy with a drainage procedure have been much better. However, as stated by Crile (1952) and by Dragstedt (1952), a recurrence rate of 5 per cent within the first year has been observed among patients with duodenal ulcer treated by vagotomy and posterior gastrojejunostomy.

Subtotal gastric resection is currently the most widely used surgical method of treating patients with duodenal ulcer. This procedure removes the antral phase of gastric secretion and a considerable portion of the parietal cell bearing area of the stomach. It is probable that the vagal phase of gastric secretion is rendered less potent by the removal of the antrum. That this may be so is suggested by the work previously cited which indicates that the cephalic phase of gastric secretion is mediated through a neurohumoral mechanism which is interfered with by removal of the antral mucosa. However, in order to achieve a sufficient lowering of gastric secretion to prevent recurrent ulceration, it is necessary to excise approximately 70 per cent of the stomach. Patients with such high resections are frequently troubled with symptoms related to the small size of their food reservoir. Farmer, Howe, Porell, and Smithwick (1951) reported that "the clinical results following removal of approximately 50 per cent of the stomach combined with vagotomy seem superior to those following more radical resections with or without vagotomy." This removal of the accessible stimulatory mechanisms of gastric secretion (gastric antrum and vagus nerves) appears to be a sound approach to the con-

trol of the gastric hypersecretion of the duodenal ulcer patient. The conversion of a "three phase" stomach to a "one phase" stomach probably lowers the ulcer potential of the gastric secretions sufficiently to prevent ulcer recurrence. This method of treatment is utilized in many patients who develop recurrent ulcer following partial gastric resection or vagotomy and gastroenterostomy.

In the absence of precise landmarks, one would probably have to do about a 40 per cent partial distal gastrectomy to be certain of removing all the antrum. If it is assumed that high subtotal resection of the stomach and the combined procedures of vagotomy and antrectomy are equal in their ability to lower the ulcer potential of the gastric secretions to safe levels, the decision as to which of these methods is preferable must be based upon whether patients do better with one method of treatment as compared to the other. Would the patient with a small food reservoir following high subtotal resection be better off to have twice as large a food reservoir but be subject to the possible undesirable side effects of vagotomy, such as diarrhea and gastric stasis? Clinical data are at present insufficient to allow an answer of this important question. Investigations of this type can go only so far in the experimental laboratory. The answer must come from further careful clinical trial of the combined procedure of vagotomy and antrum resection in the treatment of duodenal ulcer patients.

SUMMARY

This report summarizes our experience with the total parietal cell pouch as a means of producing experimental peptic ulcer. Although involving an initial operative procedure of considerable magnitude, the preparation has proved to be a useful method in evaluating the relation of the physiologic stimulatory mechanisms (cephalic, antral, and intestinal) to the development of experimental peptic ulceration. With this preparation the antral phase seems to be predominant. An important advantage of the method is that dogs protected from ulcer development survive in good nutritional status with a minimum of special care for prolonged periods. Pouches rendered practically achlorhydric to physiologic stimuli by combined vagus section and antrumectomy still respond to histamine stimulation by copious secretion of free hydrochloric acid. The experimental data clearly indicate that the ulcer potential of the gastric secretions in the absence of exogenous stimulants, as histamine, may be reduced to very low levels by the removal of the accessible stimulatory mechanisms of gastric secretion (vagus nerves and gastric antrum). It is suggested that the surgical management of gastric hypersecretion in duodenal ulcer patients by the removal of the accessible stimulatory mechanisms of gastric secretion is a procedure founded upon sound physiologic principles.

CONCLUSIONS

1. The three phase (cephalic, antral, and intestinal) total parietal cell pouch drained by an isoperistaltic jejunal fistula into the second portion of the duodenum is a potent ulcerogenic preparation in the dog.

2. Vagotomy of the pouch does not decrease the incidence of ulceration with this preparation in the dog.

3. Antrumectomy decreases the incidence of ulceration with this preparation in the dog.

4. Antrumectomy and vagotomy combined protect the dog with this preparation against the development of jejunal (stomal) ulcer.

5. The majority of dogs subjected to this procedure that do not die of ulcer complications survive in good nutritional status.

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STUDIES OF FIBROPLASIA IN WOUND HEALING

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THESE experiments were undertaken to study the growth characteristics of fibroblasts during the stimulus of wound repair. The growth potential of the new fibroblasts equaled that of a sarcoma or embryonic tissue. This explosive burst of activity slowly decreases and disappears after 4 to 6 weeks. The growth characteristics of fibroblasts in vivo are similar to those observed in vitro. A new method of procuring fibroblasts for observation and study is described.

METHODS

Hollow tantalum mesh spheres 1 centimeter in diameter were made from No. 50 mesh .003 inch tantalum wire gauze. These were implanted subcutaneously in the guinea pig with a large trocar (Fig. 1) under strict sterile precautions and ether anesthesia. Seventy-five guinea pigs, in groups of 5 and 10, weighing approximately 250 grams, were selected. They were maintained in individual cages and received a constant diet (Rockland) fortified with vitamin C (250 mgm. per 100 gm.). The animals were weighed daily and observed carefully for any clinical signs of symptoms or scurvy. During the course of the experiments guinea pigs were sacrificed at varying intervals from a few hours to many months, and the fibrous tissue around and within the mesh spheres was studied grossly, microscopically, and placed in tissue culture. Microscopic sections were stained with hematoxylin and eosin and with Mallory's aniline blue for collagen. The behavior of the proliferating fibroblasts secured at various periods in the repair process was observed in tissue culture for several weeks, or until death of the cells. At appropriate intervals permanent preparations were made by staining the cover slip upon which the fibroblasts were growing in vitro. Certain specimens were grown on a collodion membrane and transferred to a fine wire screen and placed in the electron microscope for observation and photography. The fibroblasts were cultured at 37.5 degrees C. in a mixture consisting of 4 parts of Fischer V-164 synthetic medium and 1 part of Simms's ultrafiltrate of ox blood. A small particle of dried chick embryo extract was added. Each flask contained 5 to 8 pieces of tissue and 1.0 to 1.5 cubic centimeters of medium.

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RESULTS

During the first day following implantation, the mesh spheres promptly fill with serum and fibrin and contain varying numbers of red blood cells, macrophages, leucocytes, and lymphocytes. The amount of serum and the number of blood cells are directly proportional to the amount of trauma of implantation. Fibroblasts at the periphery of the mesh begin proliferation after 24 to 36 hours (Fig. 2). There is moderate edema and hemorrhage, and acute and chronic inflammatory cell infiltration in the adjacent subcutaneous and muscle tissue. Capillaries proliferate promptly in the surrounding zone of granulation tissue. During the next 6 days there is a marked increase in the number of surrounding fibroblasts (Fig. 3), and blood vessels and proliferating nerves make their appearance. At the end of this period there is considerable adherence of the mesh to the surrounding tissue from fibrin deposits and penetration of new fibroblasts into the interstices of the wire gauze. At this time the fibroblasts are quite hyperchromatic and 2 to 4 mitoses may be seen per high power microscopic field. The fibroblasts have a rounded appearance with short cytoplasmic processes as they begin to arrange themselves parallel to the mesh, and begin to infiltrate the mesh along the fibrin strands (Fig. 5).

From the seventh to thirteenth days there is continued activity of the fibroblasts; edema and the acute inflammatory reaction begin to

Fig. 1. Method of implantation of tantalum mesh sphere using light ether anesthesia.

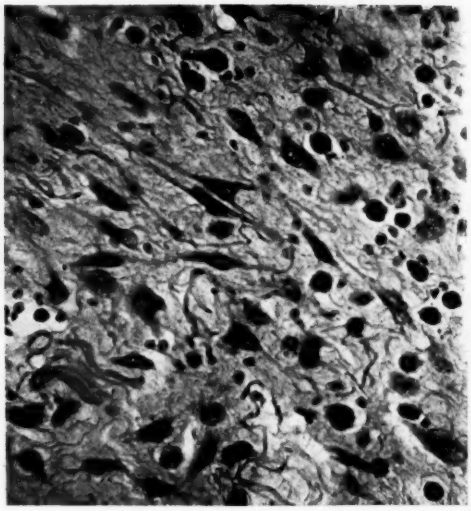

Fig. 3. Early fibroplasia around tantalum mesh sphere, 7 days after implantation. × 305.

subside; and there is increasingly firm encapsulation and adherence of the mesh to the adjacent tissue. Strands of fibroblasts and capillaries have completely penetrated the depths of the mesh along fibrin planes. Mitoses are rare and the cells have developed long processes with deposition of collagen (Fig. 7). There is invariably a small amount of bloody fluid encapsulated in the center of the mesh. During the fourteenth to twentieth days there is a decrease in the number of the acute inflammatory cells, macrophages containing blood

Fig. 2. Fibroplasia 3 days after implantation of tantalum mesh sphere.

Fig. 4. Early fibroplasia in tissue culture from fibroblasts secured 6 days after implantation. × 305.

Fig. 5. Growth of fibroblasts along a fibrin strand inside tantalum mesh sphere, 4 days following the implantation. × 305.

Fig. 7. Fibroplasia 11 days after implantation of tantalum mesh sphere. Note the parallel arrangement of cells with early collagen disposition. × 305.

pigment are prominent, and a few foreign body giant cells are formed around the edges of the wire where there is a narrow zone of necrosis. There is an increase in the amount of cytoplasm of the fibroblasts (Fig. 9), collagen deposition is prominent, and growth potential is definitely decreased in tissue culture.

During the fourth week the interior of the mesh, except for the variable hemorrhagic core, is completely organized with a loose net-

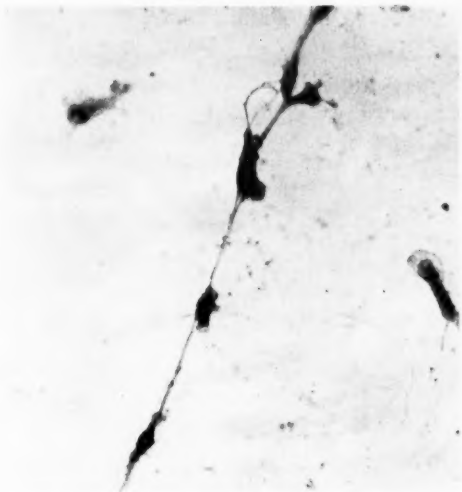

Fig. 6. Growth of fibroblasts along a fibrin strand in the tissue culture, 7 days subsequent to the implantation. × 305.

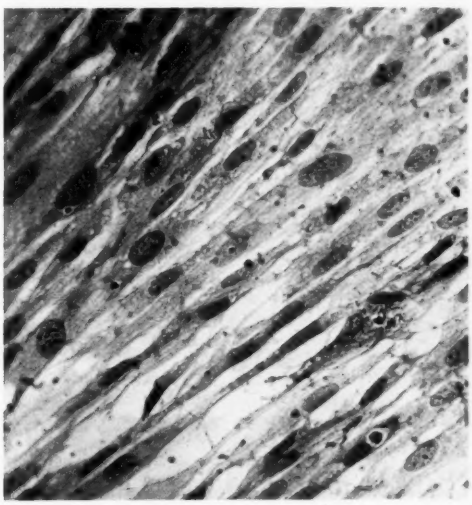

Fig. 8. Fibroplasia after 14 days in tissue culture. Note the regular parallel arrangement of cells with early lateral cohesion. × 305.

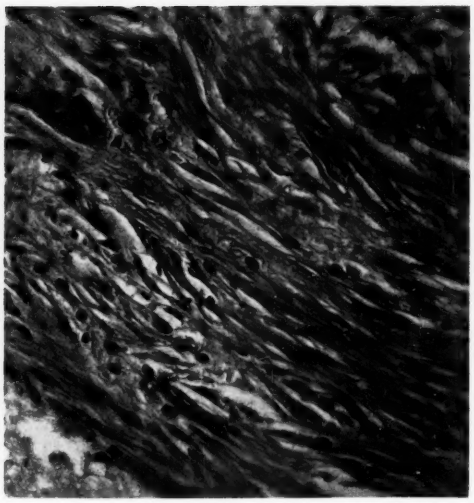

Fig. 9. Fibroplasia 21 days after implantation of tantalum mesh sphere. Note increasing density of cells and collagen formation. × 305.

Fig. 11. Fibroplasia 35 days after implantation of tantalum mesh sphere. Note extensive collagen formation, lateral cohesion, and small amount of nucleus substance.

work of rather wet myxomatous appearing fibrous tissue with a further waning of growth potential in vitro. Collagen and cytoplasmic ground substance begin to predominate as the processes of the fibroblasts have an increasingly snarled appearance with lateral cohesion (Fig. 11). At the end of 4 weeks there is beginning resorption of the hemorrhagic core and flattening of the mesh. Macrophages with blood pigment are still prominent. In from 1 to 4 months there is complete loss of growth potential of the fibroblasts in vitro. At this time their behavior is similar to cells from uninjured normal subcutaneous tissue. The mesh becomes densely encapsulated in firm fibrous tissue inside and out, and there is little or no edema. The narrow surrounding zones of necrosis about the wire persist, however, and foreign body giant cells line up around each strand (Fig. 13). At 6 months, many of the meshes have been partially extruded through the skin. No evidence of sarcoma has appeared after 12 months, despite insertion of methylcholanthrene in an additional series of 15 guinea pigs.

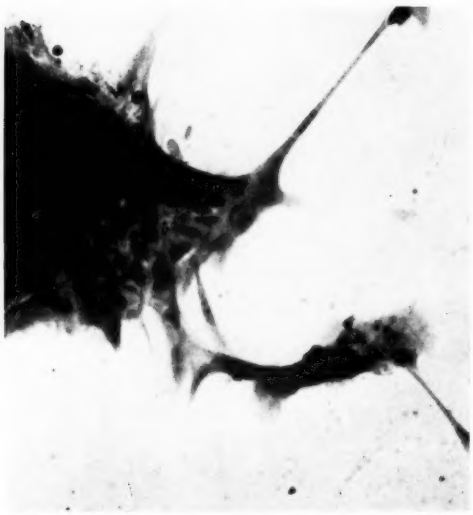

Fig. 10. Fibroplasia after 19 days in tissue culture. Note the compact border of the growing edge. × 305.

In tissue culture, the same changes in dividing and maturing fibroblasts were observed more intimately. Fibrous tissue, secured early after implantation of the mesh, shows a marked outgrowth of small, almost round cells having numerous very short processes,

Fig. 12. Fibroplasia after 30 days in tissue culture. Note the lateral cohesion of the extremely large stellate cells. × 305.

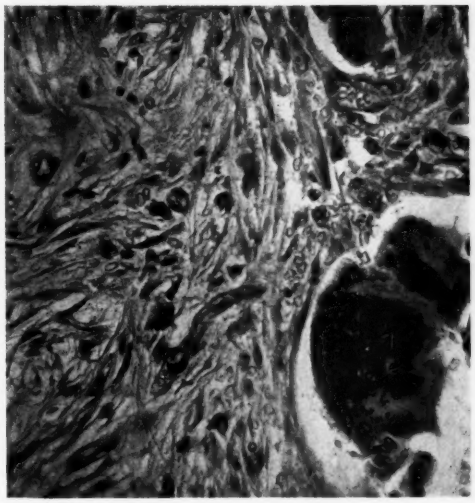

Fig. 13. Fibroplasia 40 days after implantation of tantalum mesh sphere, with giant cell formation around wire strand, and adjacent dense collagen formation. × 305.

with a growth potential equal to that of a fibrosarcoma or embryonic tissue (Fig. 4). Previous studies of embryonic and neoplastic tissue served as controls for these observations (3–5). Three to 4 days later, most of these cells have multiplied and enlarged with a spindle or triangular body with 1 to 3 long processes, often aligned on a fibrin strand (Fig. 6). A fringe of these spindle cells may be seen around each transplant. Within 2 weeks, the culture flasks are covered with an orderly sheet of spindle cells each lying in the same direction and about equidistant from each other (Fig. 8). The nucleus is oval and central. The growing edge consists of smaller, closely packed, elongated cells. Within 3 weeks there is consolidation of the orderly sheets of cells into round clumps of stellate cells, each with a round central nucleus and considerable pale cytoplasm (Fig. 10). Growing out from these clumps are long thin strands of spindle cells. Within 6 to 8 weeks extremely large stellate cells may be observed that are more acidophilic (Fig. 12). These cells soon die. It may be noted, however, that these cells have a preponderance of cytoplasmic ground substance with lateral cohesion, and resemble the older fibroblasts in vivo. Their failure to survive may result from inability to divide further and multiply, though deficiencies in the tissue culture nutrient and environment probably play a more dominant role than simple maturity.

Photomicrographs of these cells as they appear through the electron microscope reveal relatively enormous elongated cells with many long slender branching processes (Fig. 14). It is of interest to note that all of these processes are separate in space despite their solid, dense appearance at lower magnifications.

Adult fibroblasts from normal, uninjured tissue, even in the same animal carrying a mesh, grew sluggishly, if at all, in tissue culture. Fibrous tissue secured around or within the mesh, early in the course of repair, produced a new fibroblast in tissue culture that possessed a growth potential equal to that of a fibrosarcoma or embryonic tissue, as noted earlier. There was a waning growth potential of the fibroblasts secured later in the process of repair inside and around the tantalum meshes. Ultimately, fibroblasts secured after 4 to 6 weeks of growth in vivo possessed little or no growth potential in vitro and resembled the fibroblasts of normal, uninjured, subcutaneous tissue.

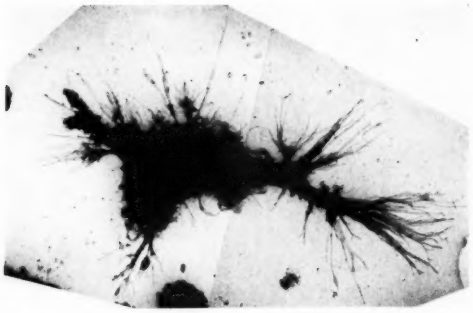

Fig. 14. A young guinea pig fibroblast from tissue culture, procured early in the course of repair. × 2486 (electron microscope).

DISCUSSION

This method has afforded a unique opportunity to study the behavior of fibroblasts in their response to trauma, a relatively inert foreign body, and the stimulus of repair without infection. The immediate burst of cellular activity subsides when repair is relatively complete. This seems to be a local, and not a systemic, phenomenon and the new fibroblasts seem to possess considerable autonomy. They seem to survive for a short period in the anterior chamber of the guinea pig eye, though a tantalum coil in the anterior chamber of the guinea pig's eye fails to elicit a fibroblastic response. Grindlay and Waugh have described the fibroblastic response to a pure white polyvinyl sponge that contains many small irregular interstices. These sponges were infiltrated by fibroblasts in a manner similar to our tantalum mesh spheres. On review of some of the microscopic preparations kindly sent to us by Dr. Grindlay, there is much less acute inflammation and no foreign body reaction in and around the sponge. Apparently fibroblastic proliferation ceased when the sponge was encapsulated and infiltrated. Presumably, therefore, physical factors relating to surface tension and lateral cohesion in space may be important in fibroblastic stimulus or repression. In vitro, collagen dissociation and reconstitution was accomplished by Vanamee and Porter by variations in *p*H and neutral salt concentrations. Thus, considering a fibroblast a primitive mesenchymal unit, its response may be governed by relatively simple physical changes. These changes are being investigated at present.

Sanford has described the transformation of normal mouse fibroblasts to cells in tissue culture that will occasionally produce a sarcoma when reimplanted back to the mouse. This has occurred with and without the addition of methylcholanthrene to the tissue culture media. This transformation occurs after several weeks or months, when the initially sluggish fibroblasts acquire a growth potential sufficient to enable them to metastasize and kill their host on repeated reinoculations. These potentially malignant mouse fibroblasts in vitro at this time appear somewhat similar to our guinea pig fibroblasts that are growing rapidly in tissue culture under the stimulus of repair. However, the latter growth process seems to be an orderly one, and we have interpreted it as the normal development, growth, and maturation of fibroblasts under the stimulus of repair and the adverse circumstances of tissue culture. Similar appearing cells may be found in vivo at about the same intervals of time around the tantalum mesh spheres. We have not transplanted these cells back into the guinea pig, though meshes allowed to remain in situ for 12 months with and without methylcholanthrene have failed to produce a sarcoma in any of the animals.

Tantalum mesh wire is not physiologically inert and evokes a typical foreign body response with dense fibrosis in the guinea pig. Its use has been described by numerous surgeons in the repair of large defects, and the fibroblastic response described. Infections in our experimental animals were rare, though when they occurred there was a complete destruction of the new fibroblasts within the mesh sphere. Outside the mesh sphere, however, there was a much more dense fibrous capsule. This should have important clinical implications favoring the use of wire mesh sheets in the presence of infection, even though infection has proved to be, in our experience, the most potent destructive agent for young rapidly proliferating fibroblasts.

SUMMARY AND CONCLUSIONS

1. Tantalum mesh spheres, implanted subcutaneously, were utilized to study tissue reac-

on and fibroblastic response to the influence trauma and repair in the guinea pig.

2. Observations were made grossly, microopically, and in tissue culture.

3. Growth potential in vitro of the fibroblasts under the stimulus of repair is at first qual to that of a sarcoma or embryonic tissue.

4. This explosive burst of cellular activity ecreases and disappears after 4 to 6 weeks.

5. There was considerable similarity in the ehavior of a fibroblast in vivo and in vitro.

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THE RETROPUBIC APPROACH TO VESICAL NECK OBSTRUCTION IN CHILDREN

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CONGENITAL vesical neck obstruction in children is an important entity which, though not difficult to diagnose, can be easily overlooked. The possibility of some type of obstructive uropathy should be considered in the differential diagnosis of every child with difficult urination and in the febrile child in whom a diagnosis is not readily evident.

With the advances in endoscopy in children, largely due to the improved small lens systems now available, these lesions can be much more easily diagnosed. Most articles on treatment have dealt with transurethral resection of the obstructing tissue, but this operation still leaves a great deal to be desired.

Lich and Maurer in 1950 reported 5 cases in which the retropubic route had been used for exposure and excision of obstructive lesions. Burns (1), in evaluating retropubic prostatectomy, pointed out that obstruction at the vesical neck and posterior urethra in male children could well be approached by this route, and in February, 1952 he (2) commented on 20 patients treated in this manner. Interestingly enough, this would seem to be the most satisfactory open surgical means of approaching this region in children, except for dividing the symphysis pubis and then directly incising the prostate. Neither the transurethral, perineal, nor suprapubic route offers as effective an approach.

One's first thought about an open operation for correcting these defects is that it appears to be an overly extensive operation when they can be attacked successfully by transurethral methods. This is true in many cases, some of these lesions being best managed transurethrally. However, with the small resectoscopes used for children, the surgeon is considerably more limited in the adequacy of the resection than he is in transurethral resection of an adult benign prostatic hypertrophy or contracted vesical neck. With the No. 16 Fr. resectoscope, the foroblique view is the only easily available one. With the Thompson instrument, the direct view alone is obtained. The small resectoscope can be inserted into the bladder of the smallest infant, by external urethrostomy if necessary, the vesical neck seen, and pieces of tissue removed. However, the instrument is almost too small to allow adequate removal of the obstructing tissue and probably as much can be done with a wire electrode through a larger cystoscope as with the resectoscope loop. The bladder neck and interureteric ridge can be incised with the miniature Collings knife transurethrally, but it is still difficult accurately to determine the limits of the incision, and the obstruction is frequently only partially relieved. Admittedly, the structures are no larger through a retropubic incision than through the resectoscope, but they are under direct control. An open surgical procedure is a more physiological procedure than electroresection. The disadvantages of electroresection of the vesical neck lie largely in the resulting burn and danger of necrosis due to deeper tissue destruction. These injuries have caused vesicovaginal fistulas in the female, and the danger of rectourethral fistula in the male is ever present. These drawbacks can be somewhat obviated by the use of the No. 16 Fr. Thompson punch. The precision of operation with small surgical instruments equals, and probably surpasses, that obtainable with a loop electrode.

The most commonly seen congenital lesions of the bladder neck fall into one of two major classifications, a division made by Emmett and Helmholtz, important because the prognosis varies greatly. The first group is the congenital, mechanically obstructed vesical neck; the second is the less favorable neuromuscular imbalance of the detrusor and sphinc-

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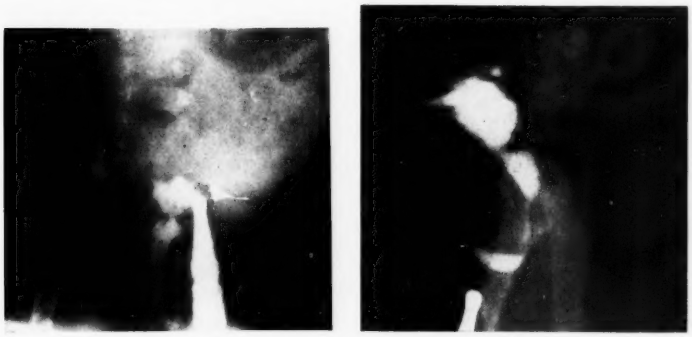

a b

Fig. 1. Case R.B. a, Cystourethrogram, anteroposterior view. The opaque medium had been injected through the cystotomy. The hourglass appearance of the bladder and the prostatic urethra is produced by the marked vesical neck contracture. b, Oblique view. Note the elevation of the posterior lip of the vesical neck.

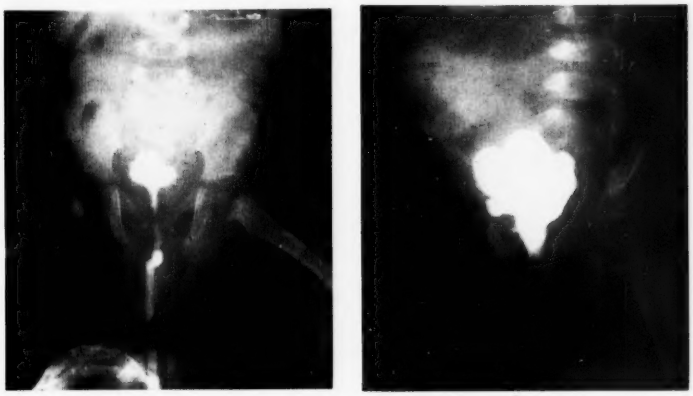

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Fig. 2. Case R.B. a, Postoperative cystourethrogram, anteroposterior view, showing funnel-shaped prostatic urethra and vesical neck. b, Oblique view, showing postoperative appearance of the vesical neck.

ter secondary to myelodysplasia or associated with spina bifida and frequently with myelomeningocele. Mechanical obstructions include congenital valves of the posterior urethra, hypertrophy of the interureteric ridge, adenomas of the prostate, and abnormalities of the verumontanum, such as hypertrophy, polyps, or perhaps persistent muellerian duct remnants. These conditions can be attacked more directly, and the results of treatment and prognosis are proportionately better.

The cause of vesical neck contracture is somewhat obscure. Actually the severity of the basic anomaly is usually not nearly as great as the secondary changes in the proximal urinary tract would lead one to suspect. It is the location rather than the degree of this minor developmental abnormality that accounts for its seriousness. Hypertrophy of the interureteric ridge and the production of a sac-like reservoir, the bas-fond are important secondary changes. The ridge may become, in itself, an obstructing flap over the vesical neck, as in the case of a 4 month old child reported by Grant. The hypertrophy is probably secondary to a vesical neck or distal obstruction and is merely the fixed upper edge of the trigone which by its anatomical nature

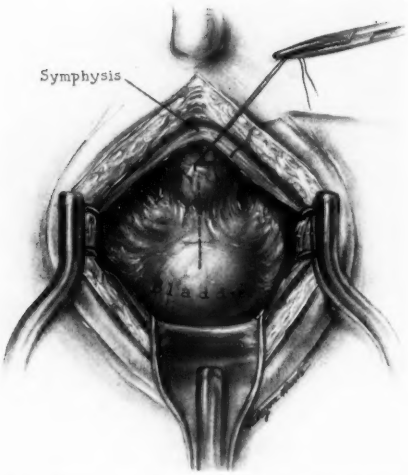

Fig. 3. Drawing of the retropubic exposure of prostatic urethra and bladder. The line of incision is indicated. Limiting suture is placed to avoid distal splitting of the capsule.

can never participate in the trabeculation and cellule formation that occurs in the distensible portion of the bladder. Valves in the prostatic urethra, taking their origin from the verumontanum and being attached to the lateral walls, represent again only minor deformities in the development of the crista urethralis and have been well classified (3). Probably many more valves have been diagnosed cystoscopically than actually exist, and in all probability, many previously undiagnosed or associated vesical neck contractures have escaped detection. Posterior urethral valves can easily be confused with loose, nonobstructing folds of mucous membrane. All in all, these valves are probably a good deal rarer than was previously supposed, and vesical neck contracture is probably more common. The rarity of valves has been attributed to the fact that they cause such severe upper urinary tract damage during the last months of intrauterine life that the renal parenchyma remaining at birth is insufficient to support life. Occasionally, hypertrophy of the verumontanum may be seen, and there are reported cases which show the verumontanum itself to be most certainly obstructing. Inflammation of the verumontanum may cause it to enlarge, but obstruction produced in this manner is still problematical.

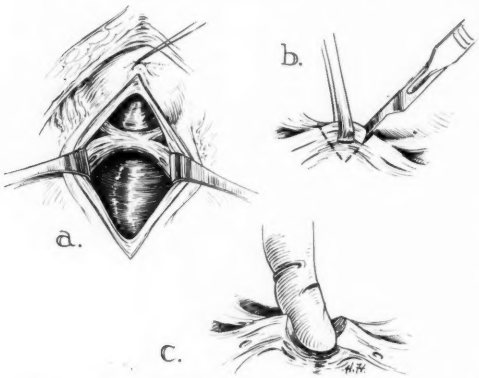

Fig. 4. a, The longitudinal capsular incision is retracted to show hypertrophied vesical neck and interureteric ridge. b, Wedge being removed from vesical neck. c, Palpation to estimate extent of obstructing lesion.

One would think the diagnosis of these tiny lesions to be quite difficult. However, all that is really required is awareness of the possibilities. These lesions are three times as frequent in males as in females. In the presence of an unexplained abdominal mass, observation of the child during urination, plus the demonstration of residual urine should put one well on the road to definitive diagnosis by cystoscopy and pyelography. In infants, residual urine can often be estimated by instilling 30 milliliters of sterile mineral oil into the bladder. The recovery of any mineral oil on the following day by catheterization indicates that urine is being retained. A careful cystoscopy with the small McCarthy foroblique lens system will many times reveal an anomaly of the vesical neck which can be corrected surgically. Even in the absence of a definite anatomical abnormality of the bladder outlet, a heavily trabeculated bladder with no other evidence of distal urethral obstruction will often indicate a responsible factor at the vesical neck. Many times in children, the classical symptoms of lower urinary tract obstruction are absent. Often an attack of pyelonephritis may be the presenting sign leading to the diagnosis of obstruction. However, the diagnosis of pyelonephritis can be obscure and it may be classified as an unexplained fever.

urinalysis in these children, with a stain of the centrifuged sediment, will usually clarify the picture. In collecting specimens for an initial microscopic examination, "mid-air" specimens in both boys and girls have been satisfactory in our hands, and certainly this avoids misdiagnosis in cases of urinary tract infection when the barrier of forcible catheterization looms large between the physician and his diagnosis. Some of these children may be presented to the urologist because of enuresis; in which case the nocturnal urination may represent an overflow incontinence. A brief neurological examination should be included when vesical neck obstruction is suspected. The history of operation for myelomeningocele or the finding of a spina bifida on urograms calls for an estimate of sensory or motor loss in the lower extremities and perineum. A mapping of sensory changes in the areas involved, in an attempt to determine their dermatome or peripheral nerve distribution, is quite helpful, and if there is involvement of the second, third, and fourth sacral segments, a relation to the innervation of the urinary sphincter may be established. It is sometimes possible to perform a cystometrogram in older children and this may provide additional information. Estimations of renal function are of the greatest importance in planning treatment and helping to determine the prognosis. Excretory urography can be done subcutaneously or intramuscularly, increasing the absorption of the dye with added hyaluronidase in order correctly to evaluate the amount of existing damage to the kidneys and ureters. The greatest limiting factor in treatment is the extent of the damage to the upper tract at birth.

CASE REPORT

R.B., a male negro infant, was born at Stanford University Hospital by uncomplicated breech delivery on January 24, 1951. Examination at birth disclosed a large, firm, lower abdominal midline mass extending to the umbilicus, and large flank masses bilaterally. The infant did not urinate for 12 hours, and at the end of this time a No. 4 ureteral catheter was passed without difficulty via the urethra, and 40 milliliters of clear urine obtained. The concentration of blood urea was 65 milligrams per 100 milliliters and that of serum creatinine was 3.0 milligrams per 100 milliliters. On the second day of life, suprapubic cystostomy was performed. The child

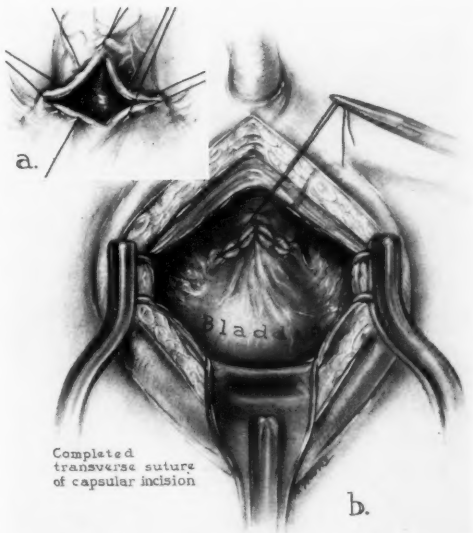

Fig. 5. a, Placement of sutures in preparation for the transverse closure of the incision. b, The completed transverse closure.

did well postoperatively and by the second week, the kidneys were no longer palpable. Cystoscopy carried out on March 10, 1951, with the miniature McCarthy panendoscope, showed the bladder to be edematous and heavily trabeculated, and the vesical neck was markedly contracted. No valves or other posterior urethral abnormalities could be identified.

At 3 months of age, he was readmitted because of right upper lobe pneumonia and moderate anemia. The level of blood urea on admission had risen to 201 milligrams per 100 milliliters. After treatment with antibiotics and transfusion, the patient began to gain weight, and the blood urea level fell to 39 milligrams per 100 milliliters. Intravenous pyelograms showed grade 2 bilateral hydronephrosis and hydroureter. Cystourethrograms showed the contracted vesical neck (Fig. 1). On June 28, 1951 the bladder and prostate were exposed through a transverse incision 1 centimeter above the pubis. The prostate was identified and incised longitudinally in the midline for about half its length. This incision was carried up on the anterior bladder wall for a distance of approximately 3 centimeters. A hypertrophied coalescence of the interureteric ridge and contracted neck was easily identified and divided in the midline. The vesical neck was markedly relaxed.

Postoperatively, the child did well, and after the urethral catheter was removed on the eighth postoperative day, he voided satisfactory amounts of urine with a large stream. The cystotomy wound healed promptly. Follow-up studies at 1 month showed no residual urine. Postoperative cystoure-

throgram showed a wide vesical neck (Fig. 2), and cystoscopy 6 months later showed a funnel-shaped, posterior urethra with no evidence of obstruction. The concentration of blood urea had stabilized at a level of 50 milligrams per 100 milliliters. The bilateral hydronephrosis regressed somewhat, and the child has continued to gain weight.

The surgical approach in the child consists of a longitudinal incision instead of the usual transverse one in the upper third of the prostate, and this is carried up on to the anterior wall of the bladder (Fig. 3). This exposes the posterior lip of the vesical neck and prostatic urethra as well as the trigone. The obstruction can then be evaluated by direct observation and palpation (Fig. 4). It is important in palpating with the finger to avoid further distal splitting of the capsular incision, for not only may the external sphincter be damaged, but the closure is made somewhat more difficult. A limiting suture can be placed transversely just distal to the lower margin of the incision in the prostate, but this is still not an adequate substitute for care in handling the tissues. since the incision may still split through the suture. By retracting the edges of the incision with small vein retractors, a wedge can be removed from the posterior lip, or it can be incised as can the interureteric ridge. We have never seen a valve through this incision, but the verumontanum can be identified, and if any of the three classical types of valves should be present, it would probably not be difficult to excise them. The bladder can be inspected and the thickness of the wall accurately determined. If diverticula are present, their contribution to residual urine can be assessed and dealt with. Hemostasis is accomplished by coagulation, the vessels being grasped with small, smooth forceps. The wound in the prostate and bladder is then closed transversely (Fig. 5). This presents no difficulty laterally, but in the midline it is necessary to bring the anterior bladder wall into the prostatic defect, more as a flap than as a true transverse closure, since the prostatic urethra is fairly rigid even in the small child. The sutures are best laid first and then tied. A small Penrose drain is placed in the space of Retzius, and the bladder is drained with a catheter of appropriate size via the urethra, for 8 to 10 days. Antibiotics are administered in the postoperative period as indicated. In increasing the caliber of the vesical neck, it is difficult to know what part is played by transverse closure of the longitudinal incision in the prostate and anterior bladder wall. It would certainly be possible to modify the Foley Y principle to fit this requirement.

The retropubic technique for correcting congenital obstructions at the vesical neck deserves serious consideration in planning the management of these small patients. It is a more precise and physiological operation, providing a more direct control during the surgical procedure, than can be afforded by endoscopic resection.

SUMMARY

1. The cause, diagnosis, and treatment of vesical neck obstruction in male infants and children are discussed.

2. An alternate to transurethral resection of these lesions is afforded by a retropubic approach, a longitudinal incision of the prostate and anterior bladder wall, and surgical excision of the obstruction.

3. An illustrative case is presented in which the retropubic operation was used in dealing successfully with a congenital contracture of the vesical neck in a 6 month old male infant.

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A COMPARISON OF THE HEALING OF HOMOGENOUS BANK AND AUTOGENOUS FRESH BONE GRAFTS WITH AND WITHOUT THE ADMINISTRATION OF CORTISONE

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SINCE the initial report by Inclan in 1942 on the use of refrigerated autogenous bone, the use of the bone bank, as described by Wilson (16, 17), Bush as well as other writers, has rapidly spread. There are a number of reports in the literature on the clinical use of homogenous refrigerated bone, but a relative scarcity of experimental comparisons of the healing of fresh autogenous and bank homogenous bone. The work reported here is one of a series of such experiments that have been done at the Hospital for Special Surgery to investigate this comparison.

The addition to this present study of the administration of cortisone was suggested by the reports that have appeared stating that the administration of large dosages of cortisone delayed fracture healing in rabbits and delayed wound healing and the formation of granulation tissue in human beings and rabbits. As it is generally accepted that the formation of granulation tissue is a necessary stage in bone healing, this reported action is of potential importance in contemplating surgical procedures on patients who have been receiving cortisone. It was felt desirable, however, to use in the present experiment a dosage of cortisone that was comparable to that used therapeutically in humans.

As a subsidiary experiment, sections of homogenous bank, autogenous fresh, and autogenous boiled cortical bone were placed in the paravertebral musculature at a distance from the vertebrae. This was done to compare the healing of bone when removed from contact with the skeleton.

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METHOD

Sixteen mongrel dogs were used, the average estimated age being 2.2 years and the average weight 22.7 pounds. The dogs were paired and designated by the length of time between operation and recovery of the grafts, the dogs receiving cortisone being designated as "C," e.g. dogs 2 and 2C, 4 and 4C. The dogs were sacrificed and the grafts recovered at 2, 4, 6, 8, 10, 12, 14, and 16 week intervals (Table I).

In the absence of accurate data on the effect of cortisone in dogs at the time these experiments were done, the dosage was determined as 1 milligram per pound of body weight. This was believed to be approximately the concentration of the drug in the tissues when used therapeutically in man. This amount was given intramuscularly daily, starting 2 days preoperatively and continuing until the day prior to recovery of the graft. The dogs were weighed at intervals to readjust the dosage if necessary. In addition, each of the dogs received 300,000 units of crysticillin on the day before operation and the subsequent 3 days.

The dogs were anesthetized with intravenous or intraperitoneal veterinary nembutal and both forelegs shaved and surgically prepared with full sterile technique used throughout the procedure. The left ulna was then exposed subperiosteally and, with a fine jewelers' saw, a segment approximately 1 inch in length was resected at a point approximately 2 inches from the distal end. In the defect in the ulna thus created was placed the homogenous bank graft, consisting of a segmental portion of ulna removed from a dog that had been operated upon 2 weeks previously. The segment of ulna removed was deliberately made slightly smaller than the bank graft which replaced it so

Fig. 1. Dog 4C. Five days postoperative.

that a snug graft to host fit was usually assured. The graft was additionally secured at each end by a loop of No. 35 stainless steel wire, placed through fine drill holes in the opposing ends of the graft and host bone. The periosteum was then resutured over the graft site and the incision closed. The right ulna was then exposed, and after resection of a similar segment of ulna, the bone which had been removed from the left ulna was placed in the defect as the fresh autogenous graft. This, too, was slightly larger than the defect in which it was placed, and was additionally secured with a wire loop at each end (Fig. 1). The bone removed from the right ulna was then placed in a sterile container, sealed, and stored in the bone bank for use as the homogenous graft in the dog operated upon 2 weeks later. It was felt that this method of placing the grafts would give a more accurate estimate of healing at the graft-host junction than the more commonly used inlay type of grafts.

TABLE I

Dog	Estimated age, yrs.	Sex	Weight, pounds	Daily amount cortisone, mgm.	Total dosage, mgm.
2	2	F	26		
2C	1	F	16	16	256
4	1	F	17		
4C	1	F	21	21	630
6	2½	M	34		
6C	1½	M	21	21	924
8	4	F	19		
8C	4½	M	30	30	1530
10	2	F	32		
10C	2	M	22	22	1984
12	2½	M	30		
12C	2	F	30 → 30 21 → 21		2173
14	1½	F	24		
14C	3	F	15 → 15 12 → 12		1363
16	3	F	16		
16C	1	M	15 → 15 13 → 13		1598

The left femur was then exposed subperiosteally and by using a twin bladed motor saw a full thickness strip of cortex was removed, measuring ½ by 3 inches in size. This was in turn sawed into 3 segments, each approximately 1 inch in length. One segment was placed in the bone bank to be used as the homogenous bank graft in the dog operated upon 2 weeks later. Two small drill holes were then placed in each of the 2 remaining segments, and they were sawed in half between the drill holes. The 2 halves of 1 segment were then boiled in sterile normal saline for 10 minutes. The 2 halves of each segment were then held with their cut surfaces firmly in opposition by means of a loop of No. 35 wire placed through the drill holes. The 2 grafts thus formed (boiled autogenous and fresh autogenous) were then placed in an incised pocket in the right paravertebral musculature at a distance from the vertebral column. The third graft, consisting of the segment of femoral cortex which had been removed from the dog operated upon 2 weeks previously and which had been kept in the bone bank, was then prepared in a similar manner and placed in the left paravertebral musculature (Fig. 2).

COMPLICATIONS

Two of the animals (dogs 2 and 4) developed minor superficial wound infections which healed uneventfully. In only 1 dog (8C) did the microscopic section show evidence of septic inflammation and then only in the homogenous bank graft. Neither during the clinical

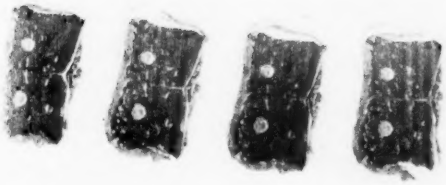

Fig. 2. Dog 6. Back homogenous bank grafts. × 1.5.

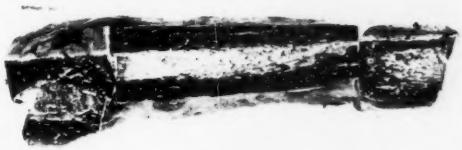

Fig. 3. Classification I. Dog 2C. Autogenous fresh graft. × 1.2.

urse nor at recovery of the grafts was evi- nce of infection seen in this animal.

In 4 of the animals (dogs 2C, 6C, 10, and 12) a wire loop broke at some time before recovery of the grafts. In each instance this occurred at the proximal end of the graft.

RESULTS

The classifications used in judging the de- e of healing of the grafts are as follows. he criteria used are admittedly rather gross t describe a process as complex as the healing o a bone graft, but they were selected as the most easily interpreted and important signs of progress toward the desired end result of solid bony union.

Classification I (Fig. 3):

1. Slight to moderate cartilaginous or bony periosteal callus and endosteal new bone formation, chiefly confined to the host bone.
2. Moderate resorption of graft surfaces and vascular spaces.
3. Slight or no invasion of ends of graft.
4. Connective tissue penetration into graft-host junction but no fibrous, cartilaginous or bony union.

Classification II (Fig. 4):

1. Advanced cartilaginous and/or bony periosteal callus, with none or early bridging between graft-host junction.
2. More marked resorption of graft surfaces and vascular spaces.
3. Moderate invasion of ends of graft.
4. Fibrous union, but no cartilaginous or bony union between graft and host.

Classification III (Fig. 5):

1. Advanced cartilaginous and bony periosteal callus with marked bony bridging at the graft-host junction.
2. Advanced resorption of the graft.
3. Advanced invasion of the graft ends.
4. One or both ends of the graft firmly united by cartilaginous callus or incomplete bony callus.

Classification IV (Fig. 6):

1. Solid bony union across the width of the graft-host junction.
2. Evidence of beginning regression of reparative processes.

As shown in Figures 7 and 8, the 2 and 4 week cortisone dogs showed a lesser degree of healing by the criteria used in both autogenous and homogenous ulnar grafts as compared with the noncortisone dogs. After this period, however, there was no consistent variation in the degree of healing. The 16 week cortisone dog, in fact, exhibited the most advanced union in the series. It is of interest, however, that the diminished healing occurred in the 2 and 4 week cortisone dogs, as it is in this early period that the reported granulation tissue blocking effect of cortisone would be expected to occur.

The comparison between the bank homogenous and the fresh autogenous ulnar grafts as such showed (Figs. 9 and 10) that the latter generally exhibited somewhat more advanced healing in the early (2 through 6 to 8 week) dogs, but that subsequent to this period the healing in the bank grafts was equal to, and in some cases superior to, that which was demonstrated in the fresh autogenous grafts.

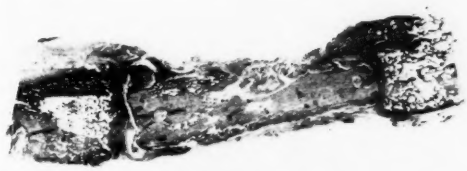

Fig. 4. Classification II. Dog 8C. Homogenous bank graft. × 1.04.

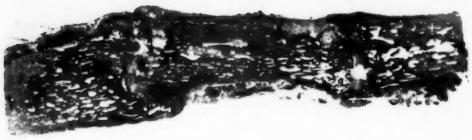

Fig. 5. Classification III. Dog 10. Autogenous fresh graft. × 1.06.

Fig. 6. Classification IV. Dog 12C. Autogenous fresh graft. × 1.16.

The evaluation of the back grafts was done in a different manner. The factors of interest there were believed to be: (1) Did the cut surfaces of the graft remain in opposition and what changes took place at this junction? (2) How much resorption of the graft occurred? (3) Was there any new bone formation or bony union across the opposing cut surfaces, in the drill holes, or on the periphery of the grafts?

Using these criteria, it was found that resorption of the bank and fresh grafts appeared to be approximately equal, while that of the boiled grafts lagged slightly behind in the early time periods. New bone formation in varying degrees occurred 8 times in the fresh autogenous and bank homogenous grafts, and 5 times in the autogenous boiled grafts. Bony union (none of which extended completely across the saw cut) occurred 3 times in the fresh autogenous bone, twice in the bank homogenous bone, and once in the boiled autogenous bone.

X-ray films of the graft areas were taken routinely throughout the postoperative period and on the day of recovery of the grafts. No consistent differences in roentgenologic evidence of union of the grafts were found. As would be expected, the appearance of the grafts on x-ray examination correlated closely with the microscopic findings. The site of poorest healing, however, was almost invariably the proximal end of the graft. This was thought to be most probably because of increased motion at this end of the graft due to the insertion of the triceps into the proximal ulna. Additional evidence for this supposition is found in the fact that in the 4 cases in which breaking of a wire loop occurred, it was at the proximal end of the graft.

DISCUSSION

Bush and Garber were the first to report on experimental comparisons between homogenous bank and autogenous fresh bone. They used rabbits and round trephine grafts taken from and replaced in the ilium as the source of bone. They reported their grafts as being successful in the following order: (1) autogenous fresh—autogenous frozen—7 days; (2) autogenous frozen—14 days, homogenous fresh, autogenous frozen—28 to 84 days; (3) homogenous frozen—7 to 84 days, autogenous boiled.

Wilson, Murray, and Way, in experiments preceding the one here reported, and using essentially the same technique of segmental ulnar grafts, reported that bony callus formation appeared earlier in the fresh autogenous than in the homogenous refrigerated bone, but at the end of 12 weeks the results of both were comparable.

Marrangoni, using cortical grafts transplanted into the radius in dogs, reported the fate of frozen homogenous and autogenous grafts to be similar, except that the former are 50 per cent slower in returning to normal consistency. He states that in the frozen homogenous transplants, there is a connective change before it is invaded by osteoblasts that accounts for the retardation of the creeping substitution.

The subsidiary experiment using the fresh, boiled, and bank grafts in the paravertebral musculature was suggested by previous work which has been done on the vitality of bone after its removal from other osseous tissue. Haas (7–9) has done considerable work on this in the past and in several papers he has studied the viability of bone placed in the

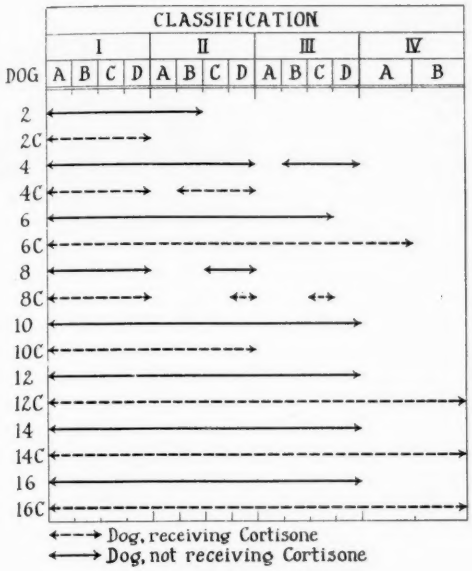

Fig. 7. Autogenous fresh grafts.

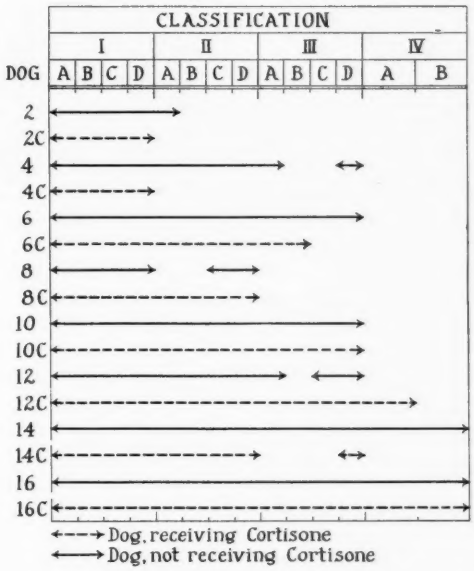

Fig. 8. Homogenous bank grafts.

paravertebral musculature after exposure to air, immersion in normal saline, maintenance at a temperature "near the freezing point" and sealed in a rubber tube and placed in the knee joint. The results were variable, but in the majority of cases evidence of osseous repair was found. He attributed this to the osteoblastic cells which he felt survived the transplanting and played an independently active role in the process of regeneration. In our experiments, however, new bone formation was found 5 times and bony union once in the boiled autogenous back grafts. It seems most unlikely that osteoblastic cells survived the boiling to contribute to the osteogenesis that was seen. It is of interest that Haas, long before the advent of the bone bank, also wrote: "In order to insure the preservation of the maximum life properties of bone after removal from the body, it is advisable to keep it at freezing temperature. It is also essential that such bone be used at an early time, as the vitality of the osteogenic cells becomes less as the time increases and is absent after five days."

In comparison with the intensive study of other actions of cortisone, its effect on bone healing has received relatively little investigation. Blunt and co-authors (3), studying femoral fractures in rabbits, reported marked retardation in repair of the fracture site after the fourth postoperative day in animals receiving 25 milligrams of cortisone daily. This tended to confirm reports by other authors on the inhibitory effect of cortisone on granulation tissue formation. The dosages of cortisone used, however, have been considerably in excess of that used therapeutically in human beings. Spain and coauthors, on the other hand, in studying the formation of granulation tissue in mice, used 2 milligrams daily and reported no significant difference in the quality or quantity of granulation tissue in comparison of the cortisone and noncortisone animals. Bangham, using relatively large dosages in mice, guinea pigs, and rabbits, reported considerable difference in the response of wound healing to cortisone in the three species studied. Blunt and Stinchfield (4), in work on dogs, found no granulation tissue blocking effect at a dosage of 7.5 milligrams per kilogram of body weight, but at 10 milligrams per kilogram the same effect was noted as was reported in rabbits by Ragan. Cole and associ-

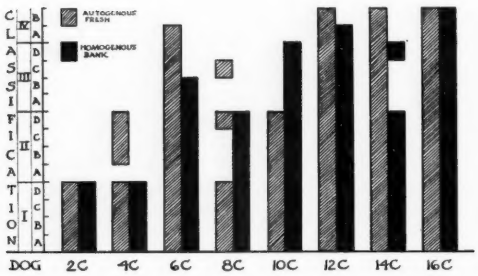

Fig. 9. Comparison of fresh autogenous with bank homogenous grafts in cortisone dogs.

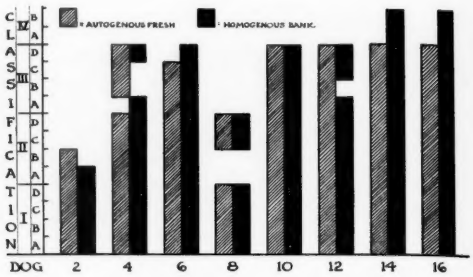

Fig. 10. Comparison of fresh autogenous with bank homogenous grafts in noncortisone dogs.

ates, using dogs receiving 2 milligrams of cortisone per kilogram of body weight daily, which was essentially the same dosage as used in this study, reported no difference in the rate or quality of wound healing between dogs receiving cortisone and control dogs.

In view of these findings, it is of considerable interest that Scheinberg and Saltzstein have reported that in 6 dogs tested a dosage of 0.5 milligram per pound of body weight caused a 50 per cent or more drop in the eosinophil count in each instance. This suggests that even this small amount of cortisone exerts a physiological effect.

There is thus considerable evidence which suggests that there exists a variable species difference in response to cortisone. It would further appear that dogs are very possibly more resistant to the effects of cortisone than human beings.

The exact explanation of the inhibiting effect of cortisone on granulation tissue is, of course, as yet unknown. It has been suggested that when hyperadrenalism is induced the mesenchymal tissue is unable to respond to trauma, as is suggested by the increased protein catabolism that is known to follow large dosages of cortisone. Baldridge, Kligman, Lipnik, and Pillsbury studied the in vitro effects of cortisone on tissue cultures of chick hearts and thigh muscles. They reported finding that proliferation of the fibroblasts was not inhibited and no cytologic alterations were evident, and that cortisone's depressant action on wound healing must be explained by some other mechanism than a direct effect on tissue.

The other factors determining the results in a study of this kind are numerous. The age of the animal, technical details of placing the grafts, and motion at the graft site all play a part in the final result and make definite conclusions difficult.

SUMMARY

1. Cortisone administration in the dosage used—1 milligram per pound of body weight—suggested early inhibition of healing in both autogenous fresh and homogenous bank ulnar grafts in the 2 and 4 week dogs. No constant effect, however, was found in later specimens up to 16 weeks.

2. In the authors' opinion, this variation in the degree of healing, although suggestive, cannot be definitely ascribed to cortisone.

3. Inasmuch as there is evidence that dogs are relatively resistant to cortisone as compared with human beings further experiments are needed to determine the effect of larger dosages of cortisone on the healing of bone.

4. The healing of bank homogenous grafts in the time periods studied, although somewhat slower to evidence repair and integration in the early stages of healing than fresh autogenous bone, in time equals and may surpass the fresh autogenous bone.

5. Portions of bone removed from other bony elements exert an osteogenic influence which is apparently independent of the survival of cellular elements as such in the bone.

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LUMBAR SYMPATHECTOMY IN THE TREATMENT OF PERIPHERAL VASCULAR DISEASES

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THE value of lumbar sympathectomy in the treatment of peripheral vascular diseases is now being recognized and accepted because of the encouraging results which are based upon the release of vasospasm and the development of small collateral vascular channels in the involved extremities. The resulting increase in the circulation provides the extremity with more oxygen and nutriments and removes the waste products from the tissues. As a result, the patient experiences relief of pain, the edema improves, the extremity becomes warm and dry, ulcers and other lesions heal more rapidly, and in those who require a major or minor amputation, the amputation can be accomplished at a lower level.

The sympathectomy does not modify or reverse the existing pathological changes in the diseased vascular channels; however, by effecting an increase in the caliber of the channels which still have elastic potentialities, improvement in circulation follows. This improvement can be measured in many ways. This elastic potentiality of the vascular channels and bed is greater than is commonly realized.

This report is an evaluation of our results of lumbar sympathectomy in a variety of conditions or diseases affecting the peripheral vessels of the lower extremities. The study involves 159 male patients upon whom 221 lumbar sympathectomies were performed from October 1946 to December 1951. Follow-up studies were obtained at various intervals postoperatively. In 41, or 25.7 per cent, of this group the operation was performed on the right side; in 56 (35.8 per cent) the operation was on the left; and in 62, or 38.5 per cent of the patients, the operation was performed bilaterally. In 3 of these patients the bilateral procedure was accomplished on the same day, whereas in the remaining group, the second procedure on the opposite side was performed usually between the seventh and the fourteenth days.

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The patients were distributed throughout the various age groups; the youngest was 20 and the oldest was 84 years of age. The greatest number were in the 51 to 60, 31 to 40, and 20 to 30 year age groups, representing 35.2, 22.6, and 17.6 per cent respectively (Table I).

The patients were classified into the following categories: arteriosclerosis (including diabetics); arterial emboli, aneurysm or thrombosis; thromboangiitis obliterans (Buerger's disease); freezing, immersion foot, and causalgia; thrombophlebitis, chronic; varicose or chronic leg ulcer; and peripheral vascular diseases of undetermined causes or types (Table I).

Arteriosclerosis (diabetics included) represented the largest number of patients in the series studied, being 31 per cent of the entire group. Buerger's disease was second in frequency with an incidence of 19.4 per cent, and chronic thrombophlebitis was the third largest group, a 14.4 per cent incidence.

SURGICAL PROCEDURE

Lumbar sympathectomies, either single or bilateral (at the same time), were usually performed under spinal anesthesia, by use of a transverse abdominal incision on either or both sides at the level of the umbilicus. The approach was extraperitoneal through a musclesplitting incision. The sympathetic ganglionated chain was usually removed from below the first lumbar ganglion to below the fourth. There are a variety of patterns in the formation of the chain and also a variation in the number of ganglia. The wound was closed in layers using silk sutures throughout. The

TABLE I.—CLASSIFICATION OF DISEASES TREATED AND AGE GROUPS

Clinical diagnosis	No. of cases	Incidence by decades							
		20–30	31–40	41–50	51–60	61–70	71–80	Over 81	Per cent of total
Arteriosclerosis (including diabetics)	49			1	26	18	3	1	30.7
Arterial emboli, aneurysms, or thrombosis	10	2	2	1	4	1			6.2
Buerger's disease (thromboangiitis obliterans)	31	5	11	5	10				19.4
Freezing, immersion foot, or causalgia	21	11	7	1	2				13.2
Thrombophlebitis, chronic	23	4	7	4	6	1	1		14.4
Varicose or chronic leg ulcer	11	3	4	1	3				6.9
Unclassified peripheral vascular disease	14	3	5	1	5				8.1
Totals*	159	28 (17.6)	36 (22.6)	14 (9.5)	56 (35.2)	20 (12.5)	4 (2.5)	1 (0.06)	

*Percentage figures given in parentheses.

patients were ambulatory on the first postoperative day. There were no postoperative hernias following this type of incision or closure. A postoperative sweating test was obtained in the majority of cases. Typical denervation was present in the majority of patients with loss of sweating below the knees anteriorly and from the sacrum posteriorly to the tips of the toes.

RESULTS

Arteriosclerosis. In this group there were 49 patients. Of this number 20 were diabetics. Seventy-two sympathectomies were performed: 13 on the right, the same number on the left, and 23 were bilateral.

The youngest was 44 years old and the oldest, 84; the average age of this group was 59.2 years. The greatest number were in the 51 to 60 year age group (Table I).

The average duration of symptoms was 18 months; the shortest was 1 week, and the longest was 20 years. In 45 patients the major and chief complaint was pain. In association with this, 21 patients also had cellulitis and 23 had chronic leg or foot ulcers. In 7 cases there was edema of the extremities. In 17 patients there was gangrene of the toes, and in 1 the gangrene involved the foot also. In 47 patients there was a diminished or absent peripheral arterial pulse (Table II).

In 37 patients tobacco was used. Of this number 25 smoked about 1 package of cigarettes daily; 7, one package per day; 1 was a heavy cigar smoker; and 1 patient chewed snuff. Ten patients did not use tobacco.

A diagnostic procaine lumbar sympathetic block was accomplished in 46 patients prior to sympathectomy. The results were considered good in 19, fair in 14, and poor in 13.

Postoperative complications developed in 11 patients. These consisted of cerebrovascular accident, embolus of the right leg, pulmonary embolism, neuritis of the anterior portion of the thigh separately in 4 patients. Paralytic ileus occurred in 3 cases; acute phlebitis in 2; and a wound infection and hematoma in 2 others.

Amputations were performed following sympathectomy in 14 of the patients who had gangrene of the toes or foot. In 6 the amputation was carried out above the knee (1 had bilateral), and in 5 patients (2 had bilateral) amputations were performed below the knee. In 2 patients transmetatarsal amputations were performed. In 2 patients amputation of the gangrenous toes was necessary. In only 1 patient of this group was a secondary closure of the stump necessary. This was required in 1 of the above knee amputations.

Postoperative sweating tests were performed in 36 patients with the result of a typical pattern in 32 cases.

The postoperative evaluation indicated that the results were excellent in 7, good in 23, fair in 13, and poor in 6 patients (Table III). In 61 per cent of those patients treated the results were rated good to excellent. This was based on an average follow-up of 11.7 months; the shortest was 5 months, the longest, 36.

Of the 6 patients who had a poor result, the average age was 67 years. In 3 patients the

TABLE II.—SYMPTOMS AND PHYSICAL FINDINGS

Clinical diagnosis	No. of cases	Pain	Ulceration	Gangrene	Cellulitis	Edema	Peripheral pulse absent or diminished
Arteriosclerosis (including diabetics)	49	45	23	18	21	7	47
Arterial emboli, aneurysm, or thrombosis	10	10		2		2	9
Buerger's disease	31	29	5	5	1	5	28
Freezing, immersion foot, or causalgia	21	18	6	4	3	2	14
Thrombophlebitis, chronic	23	18	3	2		17	15
Varicose or chronic leg ulcer	11	7	9			6	5
Unclassified peripheral vascular disease	14	11	2		2	4	9
Totals*	159	138 (86.8)	48 (30.2)	31 (19.5)	27 (17)	43 (27)	127 (79.9)

*Percentage figures given in parentheses.

gangrene of the toes continued to spread to the foot. The fourth patient showed no objective or subjective improvement following sympathectomy. In 1 patient who was 52 years of age gangrene developed after sympathectomy and required amputation above the knee. In the sixth case, the patient was 84 years of age; there was no change following surgery. This patient had an amputation above the knee which healed slowly.

Arterial embolism, aneurysm, and thrombosis, chronic. There were 10 patients in this group. Eleven sympathectomies were performed: 1 bilateral, and the others unilateral with 5 performed on the right and 4 on the left side.

The youngest patient was 22 and the oldest, 61 years old; the average age was 43 years. The greatest number were in the 51 to 60 year age group (Table I).

The average duration of symptoms was 51.5 weeks. This long period of time is based mainly on those cases with thrombosis and aneurysm. The shortest was 1 day; and the longest, 9 years.

In all cases in this series the chief and major complaint was pain. In 2 cases there was an associated edema of the extremity, and in 2 there was gangrene as a result of arterial occlusion by embolism. The arterial pulse was absent in 7 and diminished in 2 patients (Table II).

In all these patients tobacco was used; 3 smoked less than 1 package of cigarettes daily; 6, more than 1 package; and 1 smoked 2 packages daily.

Preoperative procaine lumbar blocks were performed in 6 of the 10 patients prior to sympathectomy. The results were considered good in 2, fair and poor in the same number of cases.

Amputations were performed in 2 patients in this group. One was above the knee in a patient who had an embolus of the left femoral artery. The amputation was performed on the thirteenth day following sympathectomy. In the second case, the amputation was carried out below the knee in a patient who had a gunshot wound which divided the superficial femoral artery.

Postoperative sweating tests were performed in 3 of the 10 patients with the result of 1 typical and 2 atypical denervation patterns.

The postoperative evaluation indicated that the results were excellent in 4, good in 2, and fair in 4 (Table III). In 60 per cent of the patients so treated in this group the results were rated good to excellent. This study was based on an average follow-up of 7.7 months; the shortest was 2 months and the longest, 14.

Buerger's disease (thromboangiitis obliterans). There were 31 patients in this category upon whom 51 lumbar sympathectomies were performed. Six were performed on the right side, 5 on the left, and the remaining 20 patients had bilateral operations. Of this number, 2 patients had the bilateral procedure accomplished on the same day.

The youngest patient was 25 and the oldest, 59 years old; the average age of this group was 40.7 years. The greatest number were in the 31 to 40 age group (Table I).

The average duration of symptoms prior to definitive therapy was 44 months; the short-

est was 5 weeks and the longest was 12.5 years. In 94 per cent of the patients the major and chief complaint was pain. In association with this, 5 patients had edema or an ulcer or both; 1 had cellulitis and 5 patients had gangrene of 1 or more toes (Table II). In 28 of the 30 patients there was a diminished or absent peripheral arterial pulse.

Tobacco was used by 26 of the patients. Of this number 15 smoked about 1 package of cigarettes daily and 9, one to 2 packages per day. Four patients did not use tobacco.

Sympathetic blocks were performed prior to surgery in 23 patients. The results were considered good in 19, fair in 3, and poor in 1.

Two patients complained of neuralgic pains postoperatively over the anterior aspect of the thighs on the side of the operative procedure, and 1 patient developed a draining sinus of the abdominal wound. This healed spontaneously within 30 days.

Amputations were performed in the 5 patients who had gangrene involving the toes. In 4 of these patients, local amputation of the toes involved was accomplished. In 1, a below the knee amputation was performed.

Postoperative sweating tests were performed in 22 of the 30 patients with the result of a typical denervation pattern in 19.

The postoperative evaluation indicated that the results were excellent in 14, good in 14, fair in 2, and poor in 1 (Table III). In 90.4 per cent of the patients treated in this group the results were considered good to excellent. This evaluation was based on an average follow-up of 16 months; the shortest was 1 month and the longest, 40 months. Nineteen (61 per cent) patients of this group have been followed over 2 years.

Freezing, immersion foot, and causalgia. In this group there were 21 patients. Seven were a result of freezing; 6, immersion foot; and 8 cases of causalgia. Twenty-eight sympathectomies were performed: 6 on the right, 8 on the left, and 7 bilaterally.

The youngest was 20 and the oldest, 57 years old; the average age of this group was 32 years. The greatest number were in the 20 to 30 year age group (Table I).

The average duration of symptoms was 82 weeks; the shortest was 1 week and the longest was 6 years. In 18 patients the major and chief complaint was pain. Edema was present in 2 cases: 3 exhibited cellulitis; 6 had an ulcer; and 3 cases had gangrene of toes (Table II). In 14 of the 21 patients the peripheral arterial pulse was diminished.

TABLE III.—EVALUATION OF RESULTS

Clinical diagnosis	No. of cases	Excellent	Good	Fair	Poor
Arteriosclerosis (including diabetics	49	7	23	13	6
Arterial embolism, aneurysm, or thrombosis	10	4	2	4	
Buerger's disease (thromboangiitis obliterans)	31	14	14	2	1
Freezing, immersion foot, or causalgia	21	3	14	2	2
Thrombophlebitis, chronic	23	1	7	11	4
Varicose or chronic leg ulcer	11	3	7	1	
Unclassified peripheral vascular disease	14	1	5	8	
Totals*	159	33 (20.8)	72 (45.3)	41 (25.8)	13 (8.1)

*Percentage figures given in parentheses.

All patients in this group used tobacco. Two smoked less than 1 package of cigarettes daily; 15 smoked 1 package; 3, one to 2 packages; and 1 patient smoked 4 to 5 cigars daily.

Lumbar sympathetic blocks were accomplished preoperatively in 15 in this group. In 13 the results were good; and in 2, fair.

There were 2 complications: one, a hematoma of the wound, and in the other, neuralgic pain over the anterior aspect of the thigh.

Amputations were required in 2 patients because of existing gangrene. In one the amputation was accomplished below the knees bilaterally, and in the other a transmetatarsal amputation of the left foot was performed and partial amputation of toes of right foot.

Postoperative sweating tests were performed in 14 patients with typical patterns in 12 cases.

The postoperative evaluation indicated that the results were excellent in 3, good in 14, fair in 2, and poor in 2 (Table III). In 81 per cent of the patients treated in this group the results were rated good to excellent. This evaluation was based on an average follow-up of 14.8 months; the shortest was 3 months and the longest, 36 months.

Thrombophlebitis, chronic. In this group there were 23 patients upon whom 29 sym-

pathectomies were performed: 4 on the right, 13 on the left, and 6 were bilateral.

The youngest was 22 and the oldest, 71 years old; the average age of this group was 43 years. The greatest number were in the 31 to 40 year age group (Table I).

The average duration of symptoms was 2.5 years; the shortest was 1 week and the longest, 10 years. In 18 patients the major and chief complaint was pain. In association with this, 17 had edema, 3 had ulceration of the leg, and 1 patient had gangrene of the toe and another of the foot (Table II). In 15 of the 23 patients there was a diminished or absent peripheral arterial pulse.

In 21 patients tobacco was used. Of this number 3 smoked less than 1 package of cigarettes daily; 8, one package daily; 9, one to 2 packages daily; and 1 was a moderate cigar smoker.

Sympathetic blocks were accomplished in 16 patients preoperatively. The results were considered good in 11 and fair in 5.

Postoperative complications developed in 4 patients. Three had pulmonary infarctions; in 2 of these the infarction occurred twice. In the fourth patient a left acute thrombophlebitis occurred, and ligation of left common iliac vein was performed. Of the patients who developed pulmonary infarction, 1 was treated by anticoagulants alone. In the other 2 (56 years old) patients, who had more than 1 infarction, one had a ligation of the inferior vena cava and the other, a ligation of the left common iliac vein. All 3 patients survived and no further pulmonary infarctions occurred. Both patients who had ligations developed moderate pitting edema of the extremities involved.

There were no amputations performed in this group of patients.

Postoperative sweating tests were performed in 13 patients with the result of a typical pattern in 12 cases.

The postoperative evaluation indicated that the results were excellent in 1, good in 7, fair in 11, and poor in 4 (Table III). In 35 per cent of the patients treated in this group the results were rated good to excellent. In this chronic disabling disease some improvement was apparent in 83 per cent. This evaluation was based upon an average follow-up of 16.3 months; the shortest was 1 month and the longest, 40 months.

The poor results occurred in the group of patients who required ligation of one of the large venous vessels, such as the inferior vena cava, common iliac, or femoral veins.

Varicose or chronic leg ulcer. In this group there were 11 patients upon whom 13 sympathectomies were performed: 3 on the right; 6 on the left; and in 2 cases, bilaterally.

The youngest was 21 and the oldest, 51 years old; the average age of these patients was 42.5 years. The greatest number were in the 31 to 40 age group (Table I).

The average duration of symptoms was 4 years; the shortest was 3 months and the longest, 11 years. In 9 patients the major and chief complaint was leg ulcer. In association with this, 7 complained of pain and 6 of edema. In 5 there was a diminished peripheral arterial pulse (Table II).

In 10 patients tobacco was used. In 2, less than 1 package of cigarettes was smoked daily, and in 8 at least 1 package daily.

Sympathetic blocks were performed preoperatively in 9 patients. The results were considered good in 8 and fair in 1.

One patient developed auricular fibrillation following surgery.

There were no amputations performed in this group.

Postoperative sweating tests were accomplished in all of the patients with the result of a typical pattern in 10 cases.

The postoperative evaluation indicated that the results were excellent in 3, good in 7, and fair in 1 (Table III). In 91 per cent of the patients treated in this group the results were rated good to excellent. In these cases rapid healing of the ulcer occurred following sympathectomy. This evaluation was based upon an average follow-up of 6 months.

Peripheral vascular disease unclassified. In this unclassified group of diseases of undetermined origin or cause were 14 patients upon whom 17 sympathectomies were performed: 4 on the right; 7 on the left; and 3 were bilateral.

The youngest was 22 and the oldest, 58; the average age of these patients was 39 years.

The greatest number were in the 31 to 40 and 51 to 60 year age groups (Table I).

The average duration of symptoms was 89 weeks; the shortest was 8 weeks and the longest was 22 years. In 11 patients the major and chief complaint was pain. In association with this, 4 had edema, 2 cellulitis, and 2 an ulcer of the leg. In 9 of 14 patients there was a diminished or absent peripheral arterial pulse (Table II).

All of the patients in this group used tobacco. Of this group, 1 smoked less than 1 package of cigarettes daily; 8, at least 1 package daily; 2, one to 2 packages daily; and the remaining 3 patients were moderate cigar or pipe smokers.

Preoperative sympathetic blocks were accomplished in 12 patients. The results were considered good in 9, fair in 2, and poor in 1.

One patient developed postoperative ileus. No amputations were performed in this group.

Postoperative sweating tests were performed in 8, and all of these revealed typical denervation patterns.

The postoperative evaluation indicated that the results were excellent in 1, good in 5, and fair in 8 patients (Table III). In 43 per cent of these patients treated, the results were rated good to excellent. This evaluation was based upon an average follow-up of 22 months; the shortest, 3 months; the longest, 35 months.

There was only 1 postoperative death (0.6 per cent) in the entire series of 159 patients. The death occurred on the second postoperative day and was due to pulmonary thrombosis (autopsied). This patient, who had extensive generalized arteriosclerosis, was 59 years of age. A left lumbar sympathectomy was performed. The patient was up and about with no complaints; he died suddenly while walking about the ward.

COMMENT

The overall assessment of this variety of patients with peripheral vascular diseases of the lower extremity treated by lumbar sympathectomy appears encouraging and worth while. In general, in all age groups treated, the patients experienced relief of or diminution of pain, a warmer and dry extremity, reduction of edema, clearing of the cellulitis, no further advancement of gangrene, more rapid healing of the ulcer, and in those who required amputation, whether major or minor in type, the amputation was usually performed at a lower level. In these cases the stumps healed readily, and the patients were more quickly rehabilitated.

In the entire series the results were considered good to excellent in 65 per cent and fair in 28 per cent. In the remaining 7 per cent the results were rated poor. The greatest number of most favorable results occurred in the patients with Buerger's disease, varicose or chronic leg ulcers, and freezing and immersion foot. In view of the older age group in those patients with arteriosclerotic disease of the peripheral vessels, the overall favorable results of 60 per cent are considered good. This group of patients experienced considerable relief, and the operation in many obviated a major amputation for the time being

As a group, the patients with chronic thrombophlebitis of long standing with the associated edema, chronic cellulitis, ulcer, and pain fared less favorably than any of the groups surveyed. The overall good improvement was less than 40 per cent. However, any procedure or treatment which can be carried out in this unfortunate group of patients to bring about any degree of relief or improvement is considered worth while, since the risk involved with this type of surgery is minimal. It is the opinion of one of the authors (L.T.P.), that a greater percentage of improvement can be realized in these patients if a combined procedure of lumbar sympathectomy and ligation of a large venous channel above the site of thrombotic involvement is accomplished. The rationale and physiological explanation for such an improvement are difficult to make.

The complication rate for the 221 operations was 9.5 per cent. This represents a low incidence if consideration is given the fairly large number of patients over 60 years of age in this series.

Age alone was not considered a sole determining factor in the selection of patients for sympathectomy. As seen in this study, 15 per cent of the patients were over 60 years of age; 5 patients were over 70 years old. It is

our opinion that a decision rests with the demonstration of vasospasm and with the evidence of elastic potentialities of the vascular bed, as shown by the favorable results of a lumbar sympathetic block. Any improvement in the circulation following a satisfactorily performed block, as evidenced by many factors, such as increased warmth, dryness of the skin, improvement of the symptoms and complaints, or increase in the peripheral pulse, is good preoperative evidence that a favorable result will follow a sympathectomy.

SUMMARY AND CONCLUSIONS

The effects of lumbar sympathectomy in the treatment of peripheral vascular diseases in 159 male patients upon whom 221 operations were performed from October 1946 to December 1951 are presented. This study included the following diseases or conditions: arteriosclerosis (including diabetics), arterial emboli, aneurysm or thrombosis, Buerger's disease, freezing, immersion foot, causalgia, chronic thrombophlebitis, varicose or chronic leg ulcer, and peripheral vascular diseases of undetermined type or cause.

The patients ranged from 20 to 84 years of age, the average age being 45.5 years. Fifteen per cent of the patients were over 60 years of age.

The results of the entire series were considered good to excellent in 65 per cent and fair in 28 per cent. The greatest number of patients who were benefited by the procedure were those with Buerger's disease, varicose or chronic leg ulcers, and those who had freezing, immersion foot, or causalgia. The patients who had arteriosclerotic disease of the peripheral vessels, even though their average age was greater than the above groups, revealed results which were considered good to excellent in 60 per cent of the cases.

Thirty-four per cent of the patients with chronic thrombophlebitis obtained good to excellent results following sympathectomy. In addition, 48 per cent were slightly improved following surgery.

The complication rate was less than 10 per cent in the entire series.

The favorable results are based on improvement of circulation of the extremity due to release of vasospasm and development of smaller collateral channels of the vascular bed not involved by the disease process.

Lumbar sympathectomy, in properly selected patients with the diseases or conditions studied showing a vasospastic element and an elastic potentiality of the vascular bed, resulted in early relief of symptoms, rapid healing of ulcers, diminution of edema, subsidence of cellulitis. It also prevented or delayed the need for a major amputation in many cases so that many limbs which by former standards or methods of treatment would have been sacrificed were saved. If amputation becomes necessary, frequently it can be performed at a lower level with safety, and rapid healing will usually ensue in the majority of cases.

This method of management has resulted in early rehabilitation of many patients and has reduced their period of hospitalization considerably.

ACUTE HEMORRHAGIC PANCREATITIS

Report of 11 Consecutive Cases Treated with Human Serum Albumin

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IT IS generally conceded that when the etiology of a disease is obscure, the therapeutic attack remains a challenge to the physician. Such is true of acute hemorrhagic pancreatitis. Our experience in June of 1951 prompted us to make this report of the use of salt-free human serum albumin. Accounts have appeared citing the use of human plasma with apparently encouraging results in combatting shock in pancreatitis. Our trial was based on Landsteiner's article of 1900, reporting that an antitryptic factor is contained in human serum albumin, which we therefore concluded might prove to be more specific. A recent article by Rush and Cliffton lends support to our theory by indicating the proteolytic factor in experimental pancreatitis.

A review was made of all cases of acute hemorrhagic pancreatitis seen at the Millard Fillmore Hospital from January 1949 to June 1951. From the 54 cases surveyed, all of the milder cases of acute pancreatitis with edema were eliminated. A study then was made of the remaining 19 cases of true hemorrhagic pancreatitis with necrosis and hemorrhage. The diagnoses had been confirmed by surgical observations and amylase studies. The therapy had consisted of the usually accepted procedures to combat shock, dehydration and electrolyte imbalance. Nasogastric suction, antibiotics, demerol, and nitroglycerin were used in addition to surgery to remove obstruction and establish drainage. In this group of 19 patients, 6 (or 31.6 per cent) died.

Since June 1951 it has been our good fortune to have the opportunity to study 11 consecutive cases of acute hemorrhagic pancreatitis with necrosis and hemorrhage and elevated serum amylase. In these cases we have used salt-free human serum albumin in addition to the therapy employed in the first series of patients.

In 2 of these cases laparotomy was performed with no further surgical intervention; each biliary tree appeared normal in all respects. Cholecystectomy with choledochostomy was performed in 5 because of the presence of cholecystitis and cholelithiasis. Cholecystostomies were performed on 2 patients with gangrenous gallbladders in whom resection was not feasible at the time. In 2 instances choledochostomies were performed because of apparently normal gallbladders and what appeared to be dilated common ducts; no stones were found. Beginning immediately after each operation the serum albumin was administered intravenously in from 300 to 500 cubic centimeter amounts daily for from 3 to 5 days. There seems to us to be strong clinical evidence to support our impression that the course of the disease in these patients was influenced by the albumin.

As contrasted with the group of 19 cases reviewed, in which recovery was stormy and mortality high, we have been impressed by the more benign course experienced by our series of 11 patients. An examination of the clinical and laboratory data gives evidence that the patients receiving serum albumin had a more rapid return to normal than did those in the first group who survived. The hospital stay was cut from an average of 17 days to 12 days. Rectal temperatures were reduced to normal in an average of 5.3 days as compared with the 8.9 days averaged by the first group. Return of intestinal motility, as exhibited by bowel movement or passage of flatus, was noted in an average of 4.2 days as contrasted with 6.4 days. Serum amylase determinations showed no appreciable difference, as one would predict. The white cell blood count was found to demonstrate a re-

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turn to normal limits in 5.4 days as against the average of 9.2 days exhibited by the first group. Other laboratory data were of little or no consequence.

Serum albumin should be given with caution to patients with cardiac disease, who should be watched carefully, since it has been found that the hygroscopic action of the serum may produce cardiac decompensation with pulmonary edema. One such reaction was observed in this series. Although the albumin was administered to this patient in the same dose, it was given at a slower rate, with no further untoward effects. This was the only reaction noted in the series. There were no deaths.

In July 1951 laboratory studies were undertaken in an attempt to substantiate the clinical impression derived from our experience with patients. Acute hemorrhagic pancreatitis was produced in 12 dogs by injecting into the accessory (Santorini's) duct a solution of trypsin, sodium taurocholate in sodium bicarbonate solution (0.1N). A transduodenal approach was made, locating the duct 1½ to 1¾ inches from the pylorus. This method was devised because it appeared to be less traumatic to the duct than the extraduodenal approach. When the duct was identified, a venethine tube was inserted and the solution injected. The duodenum was then closed. The serum amylase rose from normals of 16 or 32 Wohlgemuth units to postoperative levels of from 512 to 1,024 units. Each dog died within the first 12 to 48 hours following injection of the solution. Autopsy revealed acute hemorrhagic pancreatitis in each one.

A small quantity of canine serum albumin was received thereafter and was used to treat 2 other dogs in which acute hemorrhagic pancreatitis was produced in a similar manner. Each of these dogs was given 1 cubic centimeter per 3½ pounds of body weight of a solution of 1 per cent trypsin and 1 per cent sodium taurocholate in a 1/10 normal sodium bicarbonate solution. Each one had a serum amylase reading of 1,024 Wohlgemuth units. No further operative procedure was undertaken. One dog, weighing 25 pounds, was given a therapeutic dose of 25 grams of canine albumin in 100 cubic centimeters of saline solution. The second dog, weighing 60 pounds, received 12½ grams per 100 cubic centimeters of saline solution on 2 successive days. Both dogs recovered from the acute pancreatitis.

Unfortunately, the supply of canine albumin is limited at present. The study is being continued and a detailed report will be forthcoming.

SUMMARY

Although the etiology of acute hemorrhagic pancreatitis is not yet clearly understood, there is agreement that the extensive necrosis and hemorrhage observed in the pancreas are the result of the action of pancreatic enzymes which are liberated into its tissues.

It is also agreed that besides the local release of pancreatic enzymes into the pancreatic tissues, there is a sudden rise of the enzymes in the blood serum.

In 1900 Landsteiner reported the presence of an antitryptic factor in serum albumin. Later studies have emphasized the importance of antiproteolytic activity in pancreatitis.

Animated by our desire to find a substance which might act as an inhibitor to the spontaneous activation of trypsinogen to trypsin in the living tissue, we elected to use salt-free human serum albumin. In 11 consecutive cases of acute hemorrhagic pancreatitis we found impressive clinical evidence that human serum albumin influenced the course of the disease.

Acute pancreatitis was produced in 2 dogs upon which no corrective operative procedures were performed but to which proportional doses of canine serum albumin were administered with satisfactory results. It has been difficult for us to obtain canine serum for this experiment and therefore further confirmatory laboratory evidence is delayed.

We are presenting this limited experience as a preliminary report, with the hope that a more accurate and critical evaluation of this form of therapy may be forthcoming.

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A SIMPLE METHOD OF EVACUATING BLOOD CLOTS FROM THE URINARY BLADDER WITH STREPTOKINASE-STREPTODORNASE

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THE problem of retention catheters occluded by blood clots has confronted urologists for many years. In most instances intermittent irrigation of the catheter or, in more stubborn cases, irrigation and evacuation of clots with a catheter syringe suffice. However, in some instances, the catheter cannot be readily freed of obstruction, and more drastic methods must be employed. Previously this consisted of either passing a cystoscope and evacuating with an Ellik or similar evacuator, or, and not uncommonly, suprapubic cystotomy. The latter procedure requires an anesthetic and necessitates major operative intervention in patients whose circulatory status is impaired. The simple procedure of instilling an enzymatic solution for liquefying clotted debris in the catheter and evacuation of the bladder is ideally designed for this complicated situation.

The fibrinolytic activity of hemolytic streptococci was first reported by Tillett and Garner (2). Later, Christensen described a more purified and concentrated product recovered from broth cultures. Tillett and Sherry (3), working with partially purified and concentrated broth cultures of hemolytic streptococci, reported the rapid lysis of blood clots instilled in these broth cultures. Since that time, numerous publications have described various uses for streptokinase and streptodornase.[1] Among these early reports are descriptions of enzymatic liquefaction of clotted blood in patients with hemothorax. The ability of SK and SD to liquefy blood clots in the pleural cavity suggested its use for relief of clotting action in the urinary bladder.

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[1]Subsequently referred to as SK and SD.

EXPERIMENTAL STUDIES

Streptokinase-streptodornase, 100,000 and 25,000 units dissolved in 20 cubic centimeters of 0.9 normal saline, was introduced by catheter into the urinary bladders of 4 dogs and allowed to remain there until the dogs voided spontaneously. These dogs were sacrificed in 48 hours, and the bladders were removed and examined. The mucous membrane in all showed no gross evidence of any reaction.

In 4 additional dogs, the urinary bladders were opened and a 2 centimeter area of mucous membrane was surgically excised which provided a free bleeding surface. After the bleeding had ceased, SK-SD, 100,000 and 25,000 units, respectively, dissolved in 20 cubic centimeters of 0.9 normal saline, was introduced into the bladders and remained in contact with the raw surface for 5 minutes. Under direct observation it was noted that no further bleeding was provoked by the enzymes. With this experimental background of assurance, the method was employed in human cases as a means of evacuating clots in urinary bladders.

SELECTION OF CLINICAL CASES

The patients selected are of two categories: (1) those bleeding from the upper urinary tract; (2) those bleeding from the prostatic fossa, following prostatectomy. The enzyme has been used in a total of 11 patients at the University Hospital. Three were bleeding from the upper urinary tract, and 8 from the prostatic fossa, following prostatic excision. The type of prostatectomy has varied from a suprapubic or retropubic operative procedure to transurethral resection (Table I). In all cases the SK-SD solution was employed after the usual methods of irrigation had failed to free the catheter of clots.

TABLE I

Case	Age, years	Diagnosis	Etiology of bleeding	Method of instillation	Results
1	72	Benign prostatic hypertrophy	Postoperative retropubic prostatectomy	Single	Completely evacuated; no further hemorrhage
2	32	Renal calculus, left kidney	Postoperative nephrolithotomy	Repeated	Catheter remained open until patient ceased to bleed
3	68	Thrombocytopenic purpura	Hematuria, upper urinary tract	Single	Bladder cleared of clots; no further hemorrhage
4	56	Renal calculus, left kidney	Left kidney	Repeated	Catheter remained open until kidney was removed
5	77	Benign prostatic hypertrophy	Postoperative retropubic prostatectomy	Single	Completely evacuated; no further hemorrhage
6	75	Benign prostatic hypertrophy	Postoperative suprapubic prostatectomy	Single	Completely evacuated; no further hemorrhage
7	64	Carcinoma, prostate	Postoperative transurethral resection	Single	Completely evacuated; no further hemorrhage
8	66	Benign prostatic hypertrophy	Postoperative transurethral resection	Single	Completely evacuated; no further hemorrhage
9	69	Benign prostatic hypertrophy	Postoperative transurethral resection	Single	Completely evacuated but bled and occluded catheter twice more requiring 2 subsequent instillations, then no further trouble
10	73	Benign prostatic hypertrophy	Postoperative suprapubic prostatectomy	Single	Completely evacuated; no further hemorrhage
11	69	Carcinoma, prostate	Postoperative transurethral resection	Single	Unsuccessful. Drained 100 c.c. then catheter occluded and could not be unplugged

METHODS OF ADMINISTRATION

Two methods of administration have been used. A single solution of SK-SD, 100,000 and 25,000 units, dissolved in 20 cubic centimeters of 0.9 normal saline, was instilled through the catheter with a catheter syringe. The catheter was then clamped. After 15 minutes the clamp was removed and the bladder irrigated with sterile water. This method was used in all postoperative prostatectomies. During this procedure, gentle traction was maintained on the Foley catheter in order to maintain the bulb firmly against the bladder neck, and thus prevent the enzyme from coming in direct contact with the raw surfaced prostate fossa.

The second method was used in 3 patients who were bleeding from the upper urinary tract and who required repeated instillations. One vial of SK-SD solution, 100,000 and 25,000 units, dissolved in 20 cubic centimeters of 0.9 normal saline, was added to 500 cubic centimeters of 0.9 normal saline. This solution was connected to a double Y tube bladder irrigating apparatus (Fig. 1) with a second bottle containing sterile water. At hourly intervals, and subsequently at less frequent intervals, i.e., 2 hours and 4 hours, the bladder was instilled with 50 cubic centimeters of this SK-SD solution. The catheter was then clamped for 15 minutes after each instillation. When the clamp was removed, the bladder was irrigated with 50 cubic centimeters of sterile water. In the interim between irrigations, the bladder was permitted to drain spontaneously. It is necessary to employ fresh SK-SD solution every 24 hours because of the lability of the enzymes.

RESULTS

The results have been extremely gratifying in all except 1 case. In 7 patients given a single instillation, when the clamp was removed in 15 minutes, the catheter drained freely until the bladder was empty. No further difficulty was encountered with the catheter in these patients. In 1 patient in whom the single instillation method was used, although evacuation of the bladder was successful, bleeding continued, and 2 subsequent instillations were required. After the third instillation, no further hemorrhage was encountered and the patient made an uneventful recovery. In 1 patient who also had multiple bladder diverticuli, evacuation was unsuccessful. When the clamp was removed, the catheter drained

100 cubic centimeters of bloody fluid freely, and then suddenly occluded. Further efforts at irrigation failed. On removal of the catheter, it was found to be plugged with a small fragment of prostatic tissue. The resectoscope was subsequently inserted, and the contents of the bladder evacuated with an Ellik evacuator. A No. 24 Foley catheter with a 30 cubic centimeter bag was placed in the bladder. The catheter again became occluded, bleeding continued, and in spite of blood transfusions the patient lapsed into profound shock.

Under local anesthesia, a suprapubic cystotomy was performed. At operation, the catheter was found to be plugged with a small piece of prostatic tissue. The tissue, together with clotted blood, was evacuated from the bladder. Gelfoam was placed in the prostatic fossa around the Foley bag, in an effort to arrest the generalized oozing of blood. A suprapubic catheter was placed in the bladder. Death occurred several hours following operation.

In 3 patients with upper urinary tract bleeding in whom repeated irrigations were employed, no difficulty was encountered. The catheters remained patent between irrigations and there were no signs of bladder irritation. When the bleeding ceased, recovery was uneventful.

DISCUSSION

In patients with bleeding from the upper urinary tract, SK-SD solution may apparently be used with safety. This simple method of evacuating blood clots from the bladder precludes the necessity of more radical surgical procedures in patients who are usually poor surgical risks because of circulatory failure.

Bleeding from the prostatic fossa following prostatectomy presents a more difficult problem. It is to be emphasized that when enzymes are used in this type of case, gentle traction should be continually maintained on the Foley catheter. In this manner, the bag is compressed against the bladder neck and prevents the enzymatic solution from coming in contact with the actively bleeding or thrombosed vessels. The SK-SD solution might well provoke further bleeding under these circumstances, although this was not demonstrated experimentally.

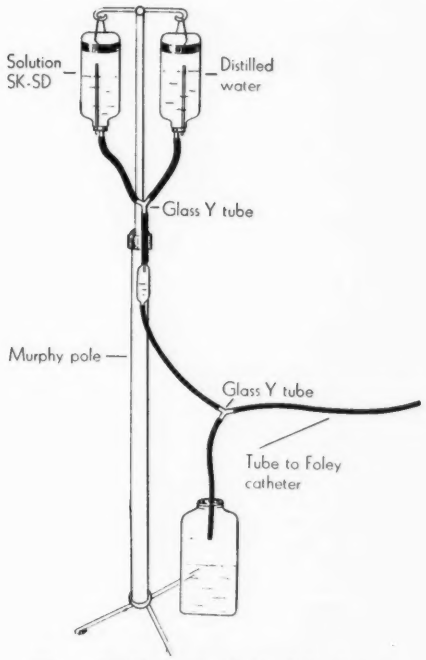

Fig. 1. Double Y tube bladder irrigation set.

In the patient who succumbed, it is surmised that numerous pieces of prostatic tissue were freed at the time of transurethral resection and became trapped in certain of the diverticula so as to prevent their evacuation. When SK-SD solution was instilled, these fragments were apparently released and plugged the catheter, preventing further drainage. Whether SK-SD solution provoked the uncontrolled hemorrhage is uncertain, but we interpret its role in the subsequent course of events as insignificant. In this regard SK-SD has been used in patients with hemothorax without undue hemorrhage. It has also been successfully used in osteomyelitis complicated by ulceration of the skin and soft tissues, in maxillary sinusitis, and in chronic ulcerative lesions of the leg without deleterious effects in regard to enhancing hemorrhage.

In instances of active bleeding from the bladder itself, such as in bladder tumors, the use of SK-SD solution may be contraindi-

cated. Enzymatic action might cause further hemorrhage or possibly enter the general circulation and consequently lead to undesirable side effects.

Clamping the catheter for 15 minutes was practiced because it is known that fresh blood clots may be lysed in that period of time. This period may be further reduced because lysis of 10 cubic centimeters of clotted blood in a test tube occurs instantaneously.

SUMMARY

1. A simple method of evacuating bladder clots by introducing SK-SD solution into the bladder is presented.

2. SK-SD solution was introduced into the urinary bladder of 8 dogs. Four normal bladders showed no evidence of reaction. Four animals in whom an area of mucous membrane had been resected showed no further bleeding following direct instillation of the enzymatic solution.

3. Eleven patients, 8 following prostatectomy and 3 bleeding from the upper urinary tract, received the treatment outlined. The results obtained were excellent in all but 1.

4. SK-SD solution did not provoke bleeding in the urinary bladder in patients with lesions higher in the urinary tract. It seems advisable when utilizing the enzymes prostatectomy to be aware of the possibility of extending bleeding, although further observations are warranted in this regard.

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AN EXPERIMENTAL EVALUATION OF BRONCHIAL ANASTOMOSIS AND HEALING WITH SPECIAL CONSIDERATION OF THE PLANE OF TRANSECTION

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THERE is much recent interest in the resection and the reconstruction of various portions of the tracheobronchial tree. In 1949, a program was outlined in this laboratory to evaluate the problem of local bronchial resection and the reconstruction of various segments of the tracheobronchial tree for the purpose of conserving functional pulmonary tissue distally. Obviously, certain criteria must be fulfilled by any surgical procedure upon the tracheobronchial tree. The end result, based upon these criteria, must provide an anatomical and functional distal unit.

The program consisted of an evaluation of suture material, suture methods, the direction of transection or resection of various tracheobronchial segments, tracheobronchial healing, and functional studies of distal pulmonary tissue. Conclusions are based upon bronchoscopic, x-ray, physiologic, and spirometric studies, and postmortem tests including gross and microscopic studies. This report is concerned only with evaluating the relationship of planes of bronchial transection to healing. A subsequent report will be made of segmental resections in various locations; functional studies following segmental resection of trachea and bronchi; and a study of the growth potentials of such procedures in young animals.

METHODS OF STUDY

Operative procedure. Sixty-five procedures were done on 49 dogs. Adult mongrel dogs were anesthetized with 30 milligrams of nembutal, per pound of body weight, intravenously. All surgical procedures were done under sterile precautions. Oxygen was supplied by a mechanical respirator. In the first cases, a regular cuffed endotracheal tube was used. A rubber balloon fixed to the end of a polyethylene tube was inserted at the time of the operation through a slit wound near the carina into the bronchus to be transected. Later, a more satisfactory endobronchial tube was constructed. A cuff of glove rubber was fixed at the end. A polyethylene tube was used to inflate the cuff after the tube was properly placed into the lumen of the bronchus not operated upon.

The thoracic cavity was entered through either the right or left fourth interspace and the lung was retracted medially and ventrally. The pleura was incised parallel to the vagus nerve. By blunt dissection the carina, main bronchus, and its first bifurcation were freed of vessels, nerves, and adventitia. A tape was placed beneath the second tracheal ring above the carina for purposes of stabilization. This maneuver is helpful in bringing the bronchial stump into a favorable position for anastomosis. The transection of the bronchus was made at the desired site and in the proper plane with a sharp scalpel or razor blade. A direct end-to-end anastomosis was performed, followed by repleuralization. The lung was reinflated by withdrawing the endobronchial tube into the trachea and applying positive pressure. Two hundred thousand units of aqueous penicillin were instilled into the pleural cavity and a three layer closure of the chest wall was performed. Secondary aspiration was uncommon. Upon withdrawal of the endobronchial tube, bronchoscopy was done in order to aspirate secretions and to evaluate the internal condition of the anastomotic line. One hundred fifty thousand units of procaine

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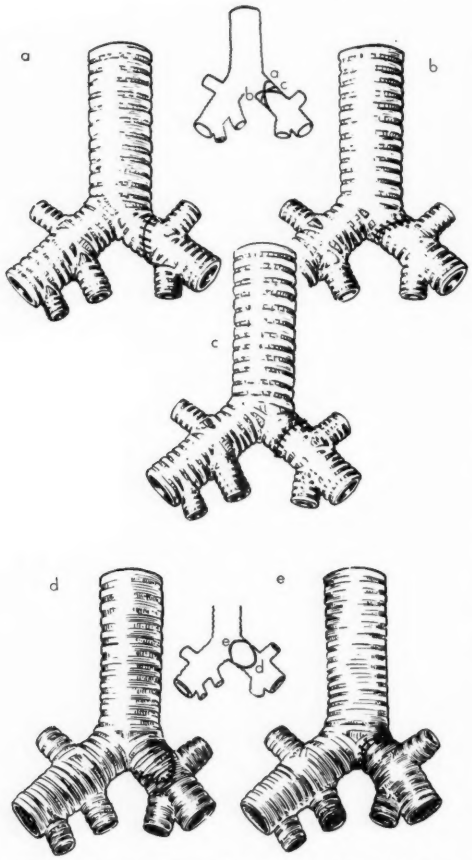

Fig. 1. Representation of the planes of bronchial transection. a, b, Two oblique superior-inferior planes. c, Transverse plane. d, e, Two anteroposterior planes.

penicillin intramuscularly was given daily for 3 days postoperatively. Food and water were allowed upon recovery from anesthesia.

Seven fresh autografts were made in the left main stem bronchus by resection of a 1 centimeter segment with immediate replacement of that segment.

Planes of bronchial transection. In this study both main bronchi were transected in 5 planes: transverse; 2 oblique, anteroposterior; and 2 oblique, superior-inferior (Fig. 1). In many cases both major bronchi were transected in the same animal after an adequate rest between operations.

Suture material. Either No. 0000 catgut, No. 0000 silk, or No. 60 cotton was used as interrupted, running and running-lock sutures. All sutures were placed through the entire thickness of the bronchial wall.

Healing studies. Serial direct visualization by bronchoscopy under pentothal anesthesia was done postoperatively in all animals at 2 weeks, monthly for 3 months, and then every 2 months for varying periods up to approximately 20 months.

At autopsy the bronchi were each subjected to air inflation under water in order to determine the pressure required to produce an air leak through the anastomotic line. In some cases at autopsy the bronchial tree was filled with a mixture of barium sulfate and plaster of paris. X-ray studies and cast specimens were obtained.

The bronchi were inspected grossly and sections were taken for microscopic evaluation of the healing process. Some of the animals were sacrificed at intervals of 3, 5, 7, 14, and 21 days postoperatively for the evaluation of early healing. Similar studies also were made in 20 other animals at varying periods up to 586 days.

RESULTS

The experiments are summarized in Tables I and II. The following criteria were utilized in the classification of each individual anastomosis:

1. Excellent, a smooth anastomotic line with complete epithelialization and no stenosis of the bronchial lumen.

2. Good, a rough anastomotic line but completely epithelialized with no granulating areas and no stenosis.

3. Fair, a rough or smooth anastomotic line with or without granulations. Stenosis if present must not reduce the luminal diameter at the anastomotic site by more than 40 per cent of the lumen proximal to the anastomosis.

4. Poor, any result not falling into the above 3 categories.

In all transection groups, the overall end results were satisfactory. There were no deaths, no perceptible pleural infections, and not a single instance of disruption of the anastomosis. Apparently, the plane of transection was relatively unimportant, since the

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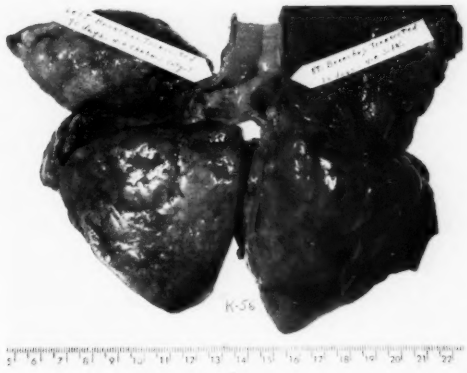
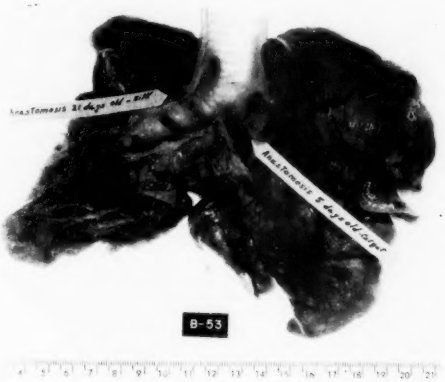


b

Fig. 2. Gross appearance of the suture line at various periods with absorbable and nonabsorbable sutures. a, Anastomosis at one week with No. 0000 silk suture. The anastomotic line is smooth. No evident epithelialization of the suture is noted. b, Specimen from an animal in which bilateral transection was done. The catgut sutures have sloughed, leaving a wide lumen. The silk sutures remain in place and are epithelialized. c, Anastomosis at 21 days with interrupted No. 0000 silk and at 5 days with No. 0000 chromic catgut. Several silk sutures are loose and some have sloughed at 21 days. The catgut sutures, at 5 days, have caused considerable reaction. Most have sloughed. d, Anastomosis at 584 days. The lumen is wide, smooth, and the lung is normal.



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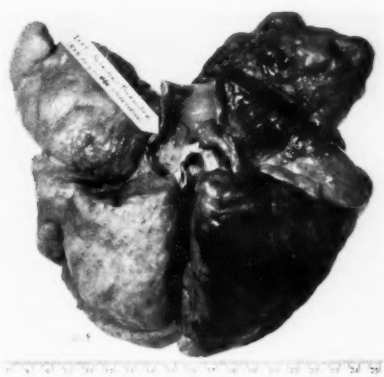

d

end results were all satisfactory regardless of the plane of transection.

Early in the program it was found that interrupted through-and-through sutures placed at intervals of 2 to 3 millimeters were the most suitable. The approximated segments produced a smoother and more stable anastomotic line. An interrupted suture, in addition, should allow for dilatation and growth at the site of anastomoses in young animals. The use of a running or running-lock suture shortened the operating time; however, both methods produced an unstable anastomosis. Overlapping of the opposing surfaces occurred frequently.

No difference was observed in the use of silk and cotton. Cotton generally was used because of its availability and low cost. In general, chromic catgut caused more cellular reaction in the early postoperative period. In most instances this material gradually was sloughed or absorbed, although evidence of

TABLE I.—SUMMARY OF EXPERIMENTS

	Dog No.	Suture	Postop. days	Result
A. Left main bronchus transected vertically (Fig. 1a)	1. K-24	4-0 chromic*	24	Excellent
	2. K-56	4-0 chromic	90	Excellent
	3. K-22	4-0 chromic	120	Excellent
	4. K-23	4-0 chromic	122	Excellent
	5. B-17	#60 cotton	533	Excellent
	6. B-18	3-0 catgut continuous lock suture	572	Excellent
B. Left main bronchus transected in a horizontal plane (Fig. 1b)	1. K-21	4-0 chromic	67	Good
	2. K-57	4-0 chromic	88	Excellent
	3. K-25	4-0 chromic	120	Excellent
	4. B-14	4-0 chromic ½ continuous and ½ interrupted	542	Excellent
	5. B-12	4-0 chromic continuous lock suture	575	Excellent
C. Right main bronchus transected in a vertical lateral plane (Fig. 1e)	1. K-57	4-0 silk	37	Excellent
	2. K-25	4-0 chromic	85	Excellent
	3. B-24	#60 cotton	562	Excellent
D. Right main bronchus transected in a vertical lateral plane (Fig. 1d)	1. M-90	4 0 silk	16	Excellent
	2. M-81	4-0 chromic	20	Excellent
	3. K-27	4-0 chromic	80	Excellent
E. Right main bronchus transected transversely (Fig. 1c)	1. K-56	4-0 silk	38	Excellent
	2. K-22	4-0 chromic	81	Excellent
	3. K-23	4-0 chromic	83	Excellent
F. Left main bronchus transected transversely (Fig. 1c)	1. B-13	4-0 chromic continuous over-and-over	543	Excellent
	2. B-11	#60 cotton continuous over-and-over	560	Good
	3. B-8	#60 cotton	584	Excellent
	4. B-5	#60 cotton continuous over-and-over	586	Excellent
G. Miscellaneous transections Left main bronchus transected transversely. Anastomosed with excess mucosa Right main bronchus transected transversely. Anastomosed with excess mucosa Right lower lobe bronchus transected transversely Left upper lobe and left lower lobe bronchi transected transversely	1. K-27	4-0 chromic	116	Excellent
	2. K-28	4-0 chromic	84	Excellent
	3. B-16	4-0 chromic	534	Excellent
	4. B-19	#60 cotton	519	Excellent
H. Left main bronchus 1 cm. resected and immediately replaced as an autograft. Transected in a vertical manner (Fig. 1a)	1. K-86	4-0 silk proximal 4-0 chromic distal	7	Died. Soft tissue necrosis and slough. Bilateral pneumonia
	2. K-79	4-0 silk proximal 4-0 chromic distal	8	Died. Soft tissue necrosis and slough. Bilateral pneumonia
	3. K-80	4-0 chromic proximal 4-0 silk distal	33	Died of distemper. Graft appeared to be intact, but rough with granulation
	4. K-26	4-0 chromic	33	Died on anesthesia for transection of right main bronchus. Abscess left lower lobe, graft site narrowed to 4 mm. diameter
	5. K-97	4-0 silk proximal 4-0 chromic distal	43	Sacrificed. Complete stricture at site of graft. Dog appeared well
	6. K-29	4-0 chromic	47	Died at operation for transection of right main bronchus. Graft site stenosed but on dissection opened up
	7. K-81	4-0 silk proximal	55	Stricture of graft to only 1–2 mm. opening. Dog appeared well

*All sutures, Tables I and II, are interrupted unless otherwise designated.

TABLE II.—SUMMARY OF EXPERIMENTS

	Dog No.	Interrupted suture	Mm. Hg pressure to produce leak	Gross findings
A. Evaluated 3 days postoperatively. Right main bronchus transected diagonally (Fig. 1a) Right main bronchus transected transversely (Fig. 1c)	1. M-78	4-0 silk	80	Fair. No stenosis
	2. M-92	4-0 chromic	90	Fair. No stenosis
	3. M-91	4-0 silk	120	Fair. No stenosis
	1. M-77	4-0 silk	80	Fair. No stenosis
	2. M-79	4-0 chromic	100	Fair. No stenosis
	3. M-88	4-0 chromic	60	Fair. No stenosis
B. Evaluated 5 days postoperatively. Right main bronchus transected diagonally (Fig. 1a) Right main bronchus transected transversely (Fig. 1c)	1. B-53	4-0 chromic	180	Fair. No stenosis
	2. M-89	4-0 silk	390	Fair. No stenosis
	3. M-76	4-0 chromic	160	Fair. No stenosis
	1. B-22	4-0 silk	120	Excellent
	2. M-71	4-0 chromic	280	Excellent
	3. K-70	4-0 chromic	230	Good
C. Evaluated 7 days postoperatively. Left main bronchus transected diagonally (Fig. 1a) Left main bronchus transected transversely (Fig. 1c)	1. K-89	4-0 chromic	290	Excellent
	2. K-90	4-0 chromic	320	Excellent
	3. B-42	4-0 silk	360	Excellent
	1. K-91	4-0 chromic	310	Excellent
	2. M-68	4-0 silk	340	Excellent
	3. M-69	4-0 silk	690	Excellent
D. Evaluated 14 days postoperatively. Left main bronchus transected diagonally (Fig. 1a) Left main bronchus transected transversely (Fig. 1c)	1. M-77	4-0 chromic	580	Excellent
	2. M-79	4-0 silk	450	Excellent
	3. M-88	4-0 silk	580	Excellent
	1. M-78	4-0 chromic	560	Excellent
	2. M-92	4-0 silk	540	Excellent
	3. M-91	4-0 chromic	520	Excellent
E. Evaluated 21 days postoperatively. Left main bronchus transected diagonally (Fig. 1a) Left main bronchus transected transversely (Fig. 1c)	1. B-22	4-0 chromic	330	Excellent
	2. M-71	4-0 silk	440	Excellent
	3. M-75	4-0 silk	600	Excellent
	1. B-53	4-0 silk	380	Excellent
	2. M-89	4-0 chromic	700*	Excellent
	3. M-76	4-0 silk	700*	Excellent

*No leak at this pressure.

chromic catgut was found microscopically at periods up to 4 to 5 months postoperatively. Cotton and silk sutures were sloughed into the lumen or covered by epithelium. In the latter, they remained as permanent fixtures.

Bronchoscopic examination revealed most anastomotic lines to remain smooth postoperatively. However, in some cases, the lumen was narrowed for periods up to several months by irregular masses of granulation tissue. These gradually resolved leaving a wide lumen with a roughened anastomotic line. In correlating this observation with the immediate postoperative appearance of the anastomosis by bronchoscopy, two definite factors appeared to retard healing; inadequate approximation of mucosa to mucosa and persistent localized infection. In those cases in which granulation tissue was seen early in the postoperative period, one could not predict which would resolve quickly and heal with a smooth line, and those which would remain rough. The cause for these variations is not known. However, if the bronchial lumen was smooth,

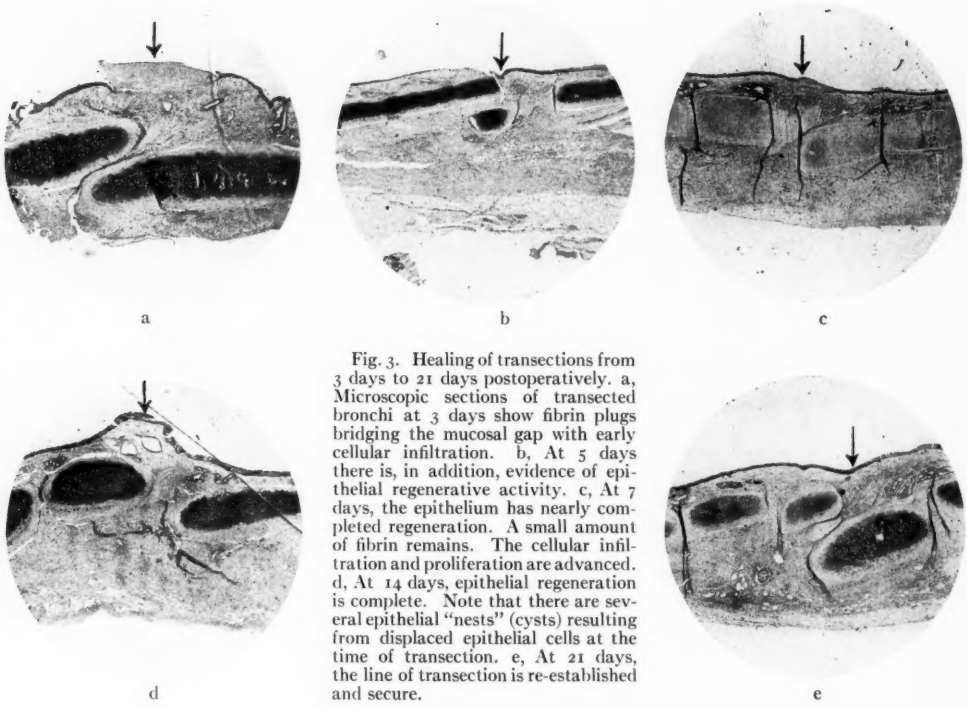

Fig. 3. Healing of transections from 3 days to 21 days postoperatively. a, Microscopic sections of transected bronchi at 3 days show fibrin plugs bridging the mucosal gap with early cellular infiltration. b, At 5 days there is, in addition, evidence of epithelial regenerative activity. c, At 7 days, the epithelium has nearly completed regeneration. A small amount of fibrin remains. The cellular infiltration and proliferation are advanced. d, At 14 days, epithelial regeneration is complete. Note that there are several epithelial "nests" (cysts) resulting from displaced epithelial cells at the time of transection. e, At 21 days, the line of transection is re-established and secure.

wide, and open for 1 or 2 months postoperatively, there was no tendency toward stenosis in animals observed up to approximately 2 years. Once established, the size of the bronchial lumen remained unchanged (Fig. 2).

Microscopically, transections examined 3 and 5 days postoperatively revealed predominately an acute inflammatory change incident to the trauma of transection and suture. At 7 days postoperatively, healing was in full progress. There was moderate fibroblastic activity and epithelial regeneration. At 14 days, the bronchial wall, with unusual exceptions, exhibited advanced healing. Healing was more prominent in the adventitia and variable in the other layers. At 21 days, the integrity of the bronchial wall was re-established with healing through all layers except the cartilage. In some of the specimens examined at 15 to 20 months postoperatively, only minor derangements of cellular layers were noted at the anastomotic site (Fig. 3).

In general, the healing rate is in inverse proportion to the amount of inflammation present. In some anastomoses, 14 to 21 days postoperative, healing was incomplete or progressing poorly. This gross evaluation was confirmed by the microscopic presence of a marked cellular inflammatory infiltrate in part of or throughout the entire bronchial wall.

The bursting strength of the suture line on the third postoperative day averaged 88 millimeters of mercury. By the fifth postoperative day, the strength more than doubled (average 227 mm. of Hg); the average strength on the seventh postoperative day was 385 millimeters of mercury; on the fourteenth day, 538 millimeters of mercury.

X-ray studies using barium sulfate, and plaster of paris casts made in some cases at autopsy revealed a smooth inner contour of the anastomotic line indistinguishable from the lumen above and below (Fig. 4).

All 7 bronchial autografts were total failures. Within the first few days postoperatively, the mucosa degenerated and areas of slough occurred. Infection occurred in the denuded areas. Granulation tissue became prominent and a distal lethal pneumonia supervened, or indolent healing occurred with a stenotic or occlusive scar. The failure of the fresh autografts undoubtedly was due to the direct interruption of the vascular supply to the graft. Even in the fresh state, the tissue becomes devitalized rapidly with autolysis and disintegration of the soft tissue portions. The persisting framework prevented the occurrence of a bronchopleural fistula, but the end result was a nonfunctional distal lung.

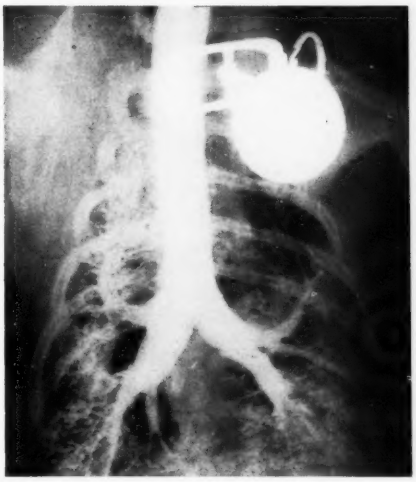

Fig. 4. Postmortem bronchogram (K-56) reveals wide functional bronchi following bilateral transection; 89 days after diagonal transection of left main bronchus in which No. 0000 chromic sutures were used and 37 days after transverse transection of right main bronchus in which No. 0000 silk sutures were used.

DISCUSSION

An evaluation of the plane of transection of the bronchus is important. The manner of interruption of the bronchial vascular supply may influence the rate and manner of healing at the anastomotic site and may limit the shaping of the proximal or distal end of the transected bronchus.

The healing of bronchial anastomoses has been shown to be unaffected by the plane of transection. The proximal or distal bronchial segment can be transected transversely or obliquely in any plane. Therefore, both bronchial ends can be tailored so that open ends of equal size are available for anastomosis.

In the experiments herein reported, only transection and anastomosis were performed. Both ends of the severed bronchus were of equal size. Therefore, no problem existed with regard to lumina disproportion. However, when one considers these experiences applied to the problem of bronchial resection, in which the opening of the distal bronchus will be smaller than the proximal lumen, the importance of this problem becomes apparent.

An analogous situation is existent in gastrointestinal surgery in which two bowel segments with unequal lumina must be anastomosed. The smaller segment is sectioned obliquely to enlarge the circumference of the lumen available for suture to the larger segment, which is cut transversely. Generally speaking, in gastrointestinal anastomoses when inequality of the segments to be approximated still exists after such maneuvers, a further adjustment in equalizing the size may be made by "puckering" the wall of the larger segment by the proper placement of stitches.

In bronchial anastomoses, a limiting factor is present in the form of semirigid cartilaginous rings. Therefore, it appears that a transverse bronchial section results in a lumen which cannot be further reduced. It is possible by the proper alignment of the membranous portions of the bronchial wall of each segment to utilize a "puckering" stitch in the membranous area. The membranous portion of the bronchus accounts normally for approximately one-fourth to one-third of the circumference of the bronchus. However, if a bronchial segment is removed, the distal bronchial lumen will be of smaller caliber. Therefore, the membranous portion will be shorter in actual millimeters than that of the proximal bronchus. Consequently, some limitation does exist.

In transecting the bronchi in the oblique planes, no regard was held for cartilaginous bronchial rings and no attempt was made to outline the vascular supply to the bronchial

wall proper. Regardless of the plane of transection, free bleeding was present from the cut surfaces of both proximal and distal segments. Bleeding from the proximal segment appeared to be more prominent.

Undoubtedly, after bronchial transection, the blood supply of the distal bronchus, even in a normal lung, must be supplied by auxiliary channels between the pulmonary and bronchial arteries within the lung substance. That such collaterals are present has been demonstrated by others. Apparently after severance of the bronchus, these vascular anastomoses are sufficient to provide active circulation to the distal bronchus adequate for nutrition and healing. This is substantiated by the results obtained.

No difference in the end result could be ascribed to the use of either catgut or silk and cotton. It should be noted, however, that no special tension on the suture line was present after mere transection and anastomosis.

The average air pressure required to produce air leak varied from 88 millimeters of mercury at 3 days postoperatively to over 525 millimeters of mercury on the twenty-first day postoperatively. Several of the anastomotic lines could not be disrupted with pressures of 700 millimeters of mercury. Therefore, the suture line appears adequate to withstand ordinary positive pressures shortly after completion of the anastomosis.

CONCLUSIONS

1. Fifty-eight bronchial transections with direct anastomoses were accomplished in dogs without mortality.

2. The plane of transection does not notably alter the healing process.

3. Interrupted through-and-through sutures of either catgut or silk and cotton are the most desirable.

4. The strength of the suture line is adequate for ordinary pressures by the third postoperative day and increases rapidly thereafter.

5. Rapid healing is promoted by careful approximation of mucosa to mucosa and protection against infection. Variations in healing existed, but the anastomotic line is completely stable by the fourteenth to twenty-first day.

6. Seven fresh bronchial autografts failed.

MENINGIOMAS OF THE POSTERIOR FOSSA

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MENINGIOMAS of the posterior cranial fossa constitute one of the most difficult diagnostic problems of present-day neurological surgery. The benign nature of these tumors and the possibility of removing them completely and successfully in many instances only serve to accentuate the problem. Meningiomas in this location have been recognized about one-tenth as frequently as supratentorial meningiomas. The great difficulty in their diagnosis makes it very likely that they are actually more common than this.

Though several authors have proposed criteria for the preoperative differentiation of meningiomas and other infratentorial tumors, in many individual cases the distinction cannot be made. Lack of such preoperative differentiation is of no great consequence, however, since the surgeon is obliged to explore the posterior fossa and will thus arrive at the correct diagnosis. On the other hand, there is a great need for the earlier detection of the meningiomas of the posterior fossa. These tumors grow so slowly that the cerebellum and brain stem adapt themselves and tolerate tremendous distortion in many instances. Thus, alarming symptoms may appear only after the tumor has grown so large that total excision is a very hazardous undertaking. With a greater awareness of the possible existence of these tumors and with a more liberal use of the newer neurosurgical diagnostic techniques, the diagnosis should be made earlier in the course of the tumor's growth. Operation at an earlier date would decrease the difficulties of excision and reduce the high operative mortality which has heretofore prevailed. In the hopes of further illuminating this diagnostic problem we have reviewed a series of 15 of our own cases from The Chicago Memorial Hospital, the Illinois Neuropsychiatric Institute, and Indiana University Medical Center, and 182 cases recorded in the literature.

From the Indiana University School of Medicine, the University of Illinois College of Medicine, and The Chicago Memorial Hospital.

REVIEW OF THE LITERATURE

Incidence and location. It appears from the literature that at least 1 out of 10 cranial meningiomas will be found in the posterior fossa, and that 1 out of 10 tumors in the posterior fossa is a meningioma. The ratio of meningiomas in the cerebellopontine angle to acoustic neurinomas is reported as 1 to 15.5 by Bager and 1 to 23 by Rasdolsky.

The sex ratio of meningiomas in the posterior fossa is 7 to 3 in favor of females. In 136 cases (our own cases included) the average age of the patient when first seeking neurological attention was 43.5 years. The ages ranged from 9 to 71 years, however, following a normal distribution curve.

As with the supratentorial meningiomas, most authors have classified meningiomas of the posterior fossa according to their location and site of dural attachment. As shown in Table I, the most frequent sites of origin are the tentorium, cerebellopontine angle, lateral recess, cerebellar convexity, and basilar groove and clivus. In some cases the direction of growth and extension of the tumor may be more important in determining the symptomatology than the site of origin or attachment of the meningioma. Tumors of the cerebellopontine angle and incisura may extend into the middle fossa. Tentorial meningiomas sometimes have both infratentorial and supratentorial components. Other meningiomas may extend through the foramen magnum into the spinal canal.

The meningiomas arising from the tentorium and lateral recess are often attached to the lateral sinus, sigmoid sinus, or torcular Herophili. The cerebellopontine angle tumors may involve the inferior petrosal sinus, and those of the basilar groove are attached to the venous plexus along the basiocciput. These venous attachments are obviously of great surgical importance.

TABLE I.—LOCATION OF 160 MENINGIOMAS OF THE POSTERIOR FOSSA

Location		No. of cases
Anterior and superior portion of posterior fossa		99
Region of fifth nerve root	5	
Incisura of tentorium	5	
Tentorium	20	
Tentorium and lateral recess	21	
Lateral recess	10	
Cerebellopontine angle	38	
Posterior portion of posterior fossa		21
Cerebellar convexity	14	
Cisterna magna	4	
Fourth ventricle	3	
Floor of posterior fossa (near midline)		29
Foramen magnum	9	
Basilar groove and clivus	20	
Subcortical (intracerebellar)		4
Multiple		7
		160

Destructive bony alterations, such as atrophy, thinning, erosion, or actual invasion of adjacent bone by the tumor, are often found with meningiomas of the posterior fossa. These changes occur most frequently in the petrous pyramid and basiocciput.

Clinical manifestations. Supratentorial meningiomas are noted for their slow growth. In general, the duration of symptoms is probably shorter in cases of infratentorial meningioma, due to their frequent embarrassment of the brain stem and the vital vagus nerve. Two thirds of the patients gave a history of symptoms of 3 years' or less duration. Remarkable exceptions were patients who had symptoms for 48 and 32 years, reported respectively by Arnvig and Petit-Dutaillis and Daum. Headache is almost universal with these tumors, occurring in at least 117 of 137 cases. There appears to be nothing about the headaches produced by meningiomas to distinguish them from other neoplasms of the posterior fossa.

Papilledema is present in about 75 per cent of patients, so in the other 25 per cent the decision to operate must be based on other neurological criteria.

Signs of cerebellar dysfunction occurred in 101 of the 137 analyzed cases. Unsteadiness of gait is the earliest, usually the predominating, and often the only sign of cerebellar dysfunction in instances of meningioma. The subjective feeling of unsteadiness experienced by the patient usually antedates and often is relatively greater than the objective unsteadiness seen by the examiner. The patient sometimes falls when in the Romberg position. Nystagmus, dysmetria, intention tremor, adiadokokinesis, and hypotonia are seen fairly frequently.

The most striking thing about the cerebellar signs is that they appear late, are often minimal, and remain in the background of the clinical picture. This fact is explained by the tumor's slow growth, allowing time for adaptation by the compressed cerebellum. In general, the cerebellar signs are more striking with the rapidly growing intrinsic tumors of the cerebellum than with meningioma.

Signs of cranial nerve involvement of one type or another are usually present with meningiomas of the posterior fossa. Evidence of damage to the eighth cranial nerve (vertigo, tinnitus, deafness, decreased vestibular response to caloric stimulation) was found in 81 of 137 cases.

Bager compared the clinical findings of 4 cerebellopontine angle meningiomas with those of 62 cases of acoustic neurinoma. The eighth nerve findings and other clinical signs were virtually identical in the 2 types of lesion. He concluded that the differentiation was impossible, except where x-ray findings were distinctive enough.

Ninety-seven of the 137 patients had signs of a lesion of one or more of the other cranial nerves. Involvement of the trigeminal nerve can produce paresthesias or sensory loss in the face, or tic douloureux. Hamby has recorded 2 cases in which tic douloureux has been produced by a meningioma contralateral to the affected trigeminal nerve. Cushing and Eisenhardt, D'Errico, and Petit-Dutaillis and Daum also report instances of hypalgesia of the side of the face contralateral to the meningioma. In the case recorded by Bailey complete section of the trigeminal nerve immediately posterior to the gasserian ganglion failed to relieve the pain, but removal of a small meningioma from the side of the pons did so.

Involvement of the facial nerve by meningiomas of the posterior fossa is fairly common. A complete facial paralysis is more apt

to occur with meningioma than with acoustic neurinoma.

The ninth, tenth, eleventh, and twelfth cranial nerves are less frequently involved by meningiomas of the posterior fossa. However, when present, lesions of the vagus nerve produce striking symptoms which are of serious import.

Compression of the brain stem gives rise to signs of pyramidal tract damage (hypertonicity, hyperreflexia, Babinski's sign, loss of abdominal skin reflexes, and weakness of the extremities), as well as occasional sensory loss, in a fair number of cases.

Tentorial tumors which extend supratentorially as well as infratentorially may compress the occipital lobe so as to give rise to homonymous field defects, and lead to exploration of the occipital lobe. This may be dangerous, because the subtentorial portion of the tumor may be responsible for the hydrocephalus.

Analysis of 111 cases of meningioma of the posterior fossa failed to show characteristic patterns of signs and symptoms of tumors in various locations within the posterior fossa. Thus prediction of the exact location of a meningioma purely on neurological findings would be hazardous.

X-ray findings. One third of the meningiomas in the posterior fossa produce changes in x-ray films of the skull. Campbell and Whitfield had positive x-ray findings in 5 out of their 9 cases. Erosion of the clivus, dilatation of the porus acusticus internus, erosion of the tip of the petrous pyramid, and hyperostosis of the pyramid have been reported.

In only a few cases is calcification within a psammomatous meningioma of the posterior fossa seen.

Other diagnostic tests. The total protein content of the spinal fluid is usually normal or mildly increased. D'Errico found an average of 35 milligrams per cent protein in 6 cases of subtentorial meningioma, in contrast to a 231 milligrams per cent average for 9 cases of acoustic neurinoma.

Ventriculography usually gives the same type of results with meningiomas of the posterior fossa as with other types of subtentorial space-occupying lesions. D'Errico, however, states that meningiomas characteristically produce a shallow doming of the undersurface of the ipsilateral temporal and occipital horns.

Wittkowsky has reported 1 case in which vertebral angiography revealed a meningioma in the posterior fossa. Hamby and Oldberg (personal communications) have each had 1 case in which vertebral angiography demonstrated the tumor. More of these tumors will surely be found by this method as the use of vertebral arteriography increases.

Thus far there have been no reports of such tumors being detected by techniques using radioactive substances.

Surgery and results. The histories of 120 patients with meningioma subjected to surgical exploration of the posterior fossa were collected from the literature and analyzed. The immediate postoperative mortality in this series is 29 per cent. The difficulties which account for this high mortality are numerous. Adherence of the tumor to the brain stem and distortions of the brain stem resulting in thrombosis or hemorrhage in the brain stem account for many deaths. For this reason, meningiomas of the clivus and basilar groove are generally conceded inoperable. Hemorrhage alone is sometimes an insurmountable problem. The attachment of the meningioma to one of the major venous sinuses increases the hazards of the operation. Resection of the lateral and sigmoid sinuses has been successfully carried out, however. Complete extirpation of the tumor is often impossible, and at least 11 per cent of the patients have died of recurrence of tumor.

The majority of surgeons have used standard bilateral or unilateral suboccipital craniectomies to expose meningiomas of the posterior fossa. D'Errico has advocated the use of a combined occipital and suboccipital osteoplastic flap to facilitate exposure of tumors involving the tentorium and sigmoid sinus. Impressed with the incidence of supratentorial extension, Olivecrona proposed removal of meningiomas of the tentorium in two stages: a suboccipital craniectomy and excision of the infratentorial portion of the

TABLE II.—AUTHORS' 15 CASES OF MENINGIOMAS OF POSTERIOR FOSSA

No.	Age and sex	Symptoms and duration	Papilledema	Neurological signs			Spinal fluid		Roentgenograms of skull	Location of tumor	Operation	Subsequent course
				Cerebellum	Cranial nerves	Long tracts	Pressure (mm. water)	Total protein (mgm. %)				
1	40 F	Suboccipital headache, 4 yrs. Numbness, R face, 1½ yr. Unsteady gait, 1½ yr. R deafness, tinnitus, 1 yr.	None	Inconstant nystagmus Positive Romberg Staggering gait	Mild R Vth hypalgesia Mild R deafness	None	200	24	Normal	Right lateral recess (Figs. 1 and 2)	None	Died ½ hour after lumbar puncture
2	44 F	Numbness tongue, 4 yrs. R facial twitching, 3 yrs. Unsteady gait, 3 yrs. Weakness R arm and leg, 1 yr. Slurred speech, 1 yr. Regurgitation of fluids through nose, 1 yr. Suboccipital headache, 1 yr. L trigeminal neuralgia, 1 yr.	None	Nystagmus R hypotonia, ataxia and adiadokokinesis	R and L decreased corneals and Vth hypalgesia Weak L masseter Weak R VII R partial deafness R and L IX palsy R and L X palsy R XI paresis L XII palsy	Decreased sensation to pin and temp., R half of body All tendon reflexes+++ R patellar and ankle clonus All abdominal reflexes o Weakness of lateral conjugate deviation of eyes, R and L	90	6	Normal	Left lateral recess, filling entire left cerebellar hemisphere (Figs. 3 and 4)	None	Died during course of x-ray therapy for presumed glioma of brain stem
3	38 M	Suboccipital headache, 10 yrs. Vertigo, 2 yrs. Vomiting, 6 months Slight R deafness, 6 months	Marked	Nystagmus, greatest to R Slightly unsteady on tandem walking	Mild R deafness Calorics normal	None	200 (6 months before admission)	45	Normal	Right lateral recess, attached to lateral sinus (Fig. 5)	Right suboccipital craniectomy. All tumor removed except small tag on lateral sinus	Did well, worked regularly for 3 yrs. postop. Attacks of unsteady gait, vomiting returned 2½ yrs. postop. Died 3 yrs. postop. at close of an exploration for recurrence
4	66 F	Regurgitation of fluids through nose, 4 yrs. Urinary incontinence, 3 yrs. Cervical and upper dorsal pain, 3 yrs. Unsteady gait, 3 yrs. Unable to walk, 1 yr. Tremor of head, 1 yr. Weakness of upper extremities, 1 yr. Unable to feed self, 9 months	None	Ataxia of both hands	R and L decreased corneals and Vth hypalgesia R deafness R and L palate paralysis	Neck muscles spastic All extremities very weak Atrophy in hands All deep reflexes increased R and L Hoffmann and Babinski o abdominals R and L astereognosis	45 (block on Queckenstedt)	182	Normal except possible thinning of anterior lip of foramen magnum	Right lateral recess (6×3 cm.)	None	Died on 21st hospital day with bronchopneumonia
5	61 F	L tinnitus, 9 yrs. L deafness, 7 yrs. L facial weakness, 5½ yrs. L trigeminal neuralgia, 2 yrs. Clonic contractions of L masticatory muscles, 2 yrs.	None	None, except suggestive intention tremor, R and L upper extremities	Complete L VII paralysis L deafness o caloric response on L	None	160	18	Bony proliferation of apex of left petrous pyramid	Left cerebellopontine angle extending into internal auditory meatus and jugular foramen Encircled Cr. N. IV, V, VII, and VIII	Left suboccipital craniectomy. Resected lateral ½ of L cerebellar hemisphere. Cr. N. IV, V, VII and VIII divided. All tumor removed	Alive and doing housework 8 years postop. Gait somewhat unsteady. Left corneal opacity

6	32 M	L deafness, 6 months Vertigo, 3 months Unsteady gait, falling to left, 3 months Suboccipital headache, 2½ mos. Somnolence, mentally dull, 1 month Vomiting, 2 days	None; only tortuous vessels	Nystagmus Ataxic gait, falling to L Adiadokokinesis and past-pointing on L	L corneal absent L VII weakness Complete L nerve type deafness o caloric response on L	None			Normal	Left cerebellopontine angle	Suboccipital craniectomy. All tumor removed except a few tags of capsule	Complete L Cr. N. V & VII paralysis. Gait nearly normal 1 yr. postop. 20 months postop. had paralysis L Cr. N. IX and X, sensory loss on R ½ of body, bilateral pyramidal and cerebellar signs. No record since then
7	64 M	L tinnitus, 10 yrs. Momentary loss of consciousness, 2 times in 3 mos. Suboccipital headache, 3 mos. Vertigo, 3 mos. Unsteady gait, 3 mos. Vomiting and hiccough, 3 mos.	None	Nystagmus Unsteady gait Unable to walk tandem Positive Romberg	L partial deafness Decreased caloric response on L	Babinski and Gonda's signs on R			Normal	Left cerebellopontine angle, arising from internal auditory meatus	Left suboccipital craniectomy. All tumor removed except a few tags 4th ventricle opened into	Cardiac irregularity immediately postop. Remained comatose. Temp. 105°F. Died 3rd postop. day
8	41 F	L frontal and orbital pain, 3 yrs. Dizzy spells, 1½ yrs. L deafness, 1½ yrs. Paresthesias, L face and arm, 1 yr. Generalized headache, 6 wks.	None	Unsteady gait Positive Romberg Tendency to fall L or backward Slight ataxia on finger to nose and heel to knee on L	Slight decrease in L corneal Very slight L VII weakness Complete L deafness o caloric response on L	Mild weakness in L arm and leg Hoffmann and Gonda on L No Babinski			Normal	Left cerebellopontine angle arising from internal auditory meatus	Suboccipital craniectomy. Removal of tumor incomplete due to excessive hemorrhage and shock	Remained comatose with right hemiplegia. Died 1st postop. day. Autopsy disclosed large basilar subdural hematoma in posterior fossa
9	22 F	Twitching L facial muscles, 7 yrs. Spells of numbness of L face and body, 6 yrs. L tinnitus, 5 yrs. Headache, 5 yrs. Dizziness, 5 yrs. Vomiting, 5 yrs. Unsteady gait, 5 yrs. Diplopia, 4 months Hoarseness, 3 months	Mild	Nystagmus Staggering gait Adiadokokinesis and hypotonia in L arm	L corneal decreased L Vth hypalgesia L masseter weak Marked L deafness o caloric response on L o gag reflex on L	Increased deep reflexes in L extremities			Erosion of left petrous pyramid with enlarged internal auditory meatus	Left cerebellopontine angle	Suboccipital craniectomy 4½ yrs. previously showed only subarachnoid cyst At 2nd operation, removal of tumor incomplete Nearly all tumor removed 1½ yrs. later	1½ yrs. after 2nd operation, had complete paralysis of L Cr. N. V, VII, VIII, IX, X, XI and XII; marked left cerebellar signs; papilledema; failing vision After 2nd operation patient had to subsist with Levin tube feedings and tracheotomy. Expired at home 6 months after 3rd operation. No autopsy
10	46 F	Suboccipital headache, 2 yrs. Nausea Vomiting in attacks Tinnitus, 9 months Dizziness Headache L face numb Difficulty in swallowing and talking for few months Poor vision	Present	None, but patient too ill for gait to be tested	R corneal weak L corneal absent L supraorbital hypalgesia R VII weakness	All deep reflexes increased □ abdominals ○ Babinski Hypalgesia R extremities and R half of body			Questionable decalcification of sella turcica	Midline, attached to under surface of tentorium, torcular and occipital sinus (Fig. 6)	Bilateral suboccipital craniectomy. 40 gm. tumor removed. Site of tumor attachment cauterized	Motor aphasia 11th to 17th postop. days. Then complete recovery. No Cr. N. weakness. No cerebellar signs. Does housework. Well 7 yrs. postop.
11	19 F	Suboccipital headache, 1 yr. Unsteady gait, falling to L, 2 months L hand clumsy, 2 weeks Stiff neck, suboccipital tenderness, vomiting, 1 week	3 D, R and L	Nystagmus, greatest on gaze to L L hypotonia, asynergia, adiadokokinesis, past pointing	L corneal absent Marked L Vth hypalgesia L masseter weak R VI weakness Slight L VII weakness Mild nerve type deafness, R and L	Decreased pin prick, cotton, vibration and position sense, entire L half of body ○ pyramidal signs			Thinning of occipital bone Pronounced digitations of inner table of vault	Left tentorium 4.5×2.5 cm. portion supratentorial in middle fossa Erosion petrous tip Infratentorial portion indenting pons and left superior cerebellar peduncle	No tumor found on exploration of posterior fossa	Continuous ventricular drainage postop. Left Cr. N. X weakness. Sudden respiratory arrest 40 days postop.

TABLE II.—AUTHORS' 15 CASES OF MENINGIOMAS OF POSTERIOR FOSSA—Continued

No.	Age and sex	Symptoms and duration	Papil-ledema	Neurological signs			Spinal fluid		Roentgenograms of skull	Location of tumor	Operation	Subsequent course
				Cerebellum	Cranial nerves	Long tracts	Pressure (mm. water)	Total protein (mgm. %)				
12	41 M	L tinnitus, 2 yrs. Occipital headache, 1 yr. Dizzy spells, 1 yr. Diplopia, 5 months Unsteady gait, nausea and vomiting, 4 months	Present	Nystagmus, greatest to R Ataxia and dysmetria of R extremities Hypotonia, R extremities Dysarthria	R and L anosmia L VI paralysis L Vth hypesthesia L motor Vth weak R lower VII weak L partial deafness 0 caloric response on L, decreased response on R Gag reflexes weak, R and L R palate weak R trapezius weak	R leg weak R Babinski Increased deep reflexes, both lower extremities	148 (2 years postop.)	13	Normal	Right cerebellar hemisphere (convexity)	Large vascular tumor, apparently infiltrating cerebellar hemisphere, partially removed	Good recovery with almost normal gait and no headaches for 1½ yrs. Then headache, vomiting and unsteady gait returned. Given 6000 r deep x-ray therapy to posterior fossa. 27 months postop. threatened and abused wife. Commitment of patient advised. No further record
13	57 F	Staggering gait, 6 yrs. Numbness of hands, 6 yrs. Dragging R foot, 5½ yrs. Paraplegia, 5 yrs. Arms weak, 2 yrs. Incontinent, few weeks R facial spasms, few weeks	None	None elicited	Bilateral optic atrophy (due to old chorioretinitis?)	Very little voluntary motion in legs Strength 50% of normal in arms C_1 sensory level All deep reflexes increased R and L Babinski R Hoffmann 0 abdominals	Complete block on Queckenstedt 280 after 1st stage	350		Foramen magnum at left anterolateral aspect of medulla and cervicomedullary junction	Complete removal in 2 stages. In 1st stage the portion of tumor in spinal canal was removed. In 2nd stage, suboccipital craniectomy was done and tumor adjacent to medulla was removed	Decreased L corneal. L Vth hypalgesia. Absent gag reflex. Continued quadriplegia. Sudden death 6 weeks postop. No autopsy
14	35 F	Atrophy rt. half of tongue, 3 yrs. Vertigo, 10 months Occipital headache, 10 months Blurred vision, right tinnitus, numbness and weakness of hands, and unsteady gait, 7 months 2 attacks of loss of consciousness, 1 month	Present	Questionable slight ataxia and adiadokokinesis on rt. Unsteady on tandem walking	Rt. XIIth N. paralysis	Decreased right arm-swing when walking	200	24.5	Normal	Right lateral recess, occupying most of right half of posterior fossa Attached to sigmoid sinus	Complete removal (piecemeal) of 75.7 gm. tumor Attachment over sigmoid sinus coagulated	Uneventful recovery. Living and well 5 months postop.
15	20 F	Headache, 4 yrs. Vertigo, 4 yrs. Convulsion, 3 yrs. preop. Awkward rt. hand, 1 yr. Nausea and vomiting, 2 wks.	Present	Nystagmus Rt. adiadokokinesis Rt. ataxia and dysmetria Unsteady gait	Rt. corneal reflex absent	Deep reflexes increased on R			Erosion, rt. petrous pyramid	Right cerebellar hemisphere (convexity)	Removal of all tumor except small portion adjacent to brain stem	Transient rt. Vth and 7th N. palsies. Complete rt. 8th N. paralysis, with subsequent partial recovery Pt. was active and felt well 3 months postop.

tumor, followed by an occipital flap and removal of any supratentorial extension.

Meningiomas arising from the incisura and projecting into both the middle and the posterior cranial fossae have been uniformly fatal.[1] Next most deadly are the meningiomas arising in the basilar groove and clivus, where the tumor is practically inaccessible for complete extirpation. Campbell and Whitfield record 2 outstanding exceptions to this rule, with 6 and 9 year survivals. Because of their involvement of the brain stem, tentorium, vagus nerve, and venous sinuses, and their invasion of bone, meningiomas of the lateral recess and cerebellopontine angle are often difficult to extirpate completely. However, Cushing and Eisenhardt recorded survivals of 4, 4, 7, and 10 years after incomplete excision. The meningiomas of the foramen magnum have been successfully removed on several occasions. Most amenable to surgical removal are the meningiomas of the convexity of the cerebellum, i.e. those arising posteroinferiorly and having little or no connection with the brain stem, sinuses, or tentorium.

Of the 56 out of 120 patients who survived operation and had no known recurrence of tumor, many were not followed for prolonged periods. However, Cushing and Eisenhardt record survivals of as long as 22 and 24 years. Though some of the patients who recovered from the operation had residual neurological defects, many were capable of earning a living.

AUTHORS' CASES

Our own series comprises 15 cases of meningioma of the posterior fossa. Five cases are from the neurosurgical service at the Chicago Memorial Hospital, 1 is from Indiana University Medical Center, and 9 are from the University of Illinois, Illinois Neuropsychiatric Institute.

[1]Within the past year we have had an exception to this statement. The case is not included herein as the meningioma extended far beyond the posterior fossa, extending from near the foramen magnum through the incisura of the tentorium to the region of the orbital fissure. It involved many of the cranial nerves on one side and invaded the dura mater at the base of the skull, including one cavernous sinus. The bulk of the tumor was removed in two stages through suboccipital and temporal exposures. The patient survives and is improving but is still seriously disabled.

Fig. 1. Case 1. View of posteroinferior surface of cerebellum, showing meningioma in right lateral recess and pressure cone of cerebellar tonsils.

Five of these meningiomas were located in the lateral recess and 5 were in the cerebellopontine angle. One meningioma was situated in the midline, attached to the tentorium, torcular Herophili, and occipital sinus; 1 was on the tentorium, with both supratentorial and infratentorial extensions; 2 were in the posterior convexity of the cerebellar hemisphere; and 1 was at the anterolateral margin of the foramen magnum.

The histories and neurological findings of these patients are summarized in Table II. The results of lumbar puncture and x-ray examination of the skull, the operative procedures performed, and the subsequent course are also given in Table II. It will be noted that at least 4 patients had normal spinal fluid pressures, and only 6 of the 15 patients had papilledema. The total protein content of the spinal fluid, when determined, was

Fig. 2. Case 1. Section of cerebellum through greatest diameter of meningioma.

Fig. 3. Case 2. View of superior surface of cerebellum, showing meningioma and its dural attachment and extension through the dura.

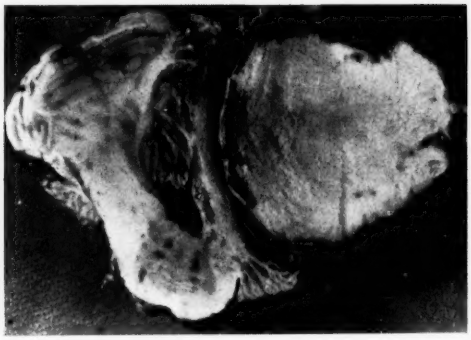

Fig. 4. Case 2. Section of the cerebellum showing replacement of the left hemisphere by meningioma and distortion of the pons.

normal except in 2 cases of spinal subarachnoid block. It is also noteworthy that in only 4 cases were changes present on x-ray examination of the skull indicative of a neoplasm in the posterior fossa. Ventriculography was done in 4 cases (Cases 3, 10, 14, and 15), in all of which there was dilatation of the lateral and third ventricles. In 2 cases the fourth ventricle failed to fill, in 1 patient (Case 14) the fourth ventricle was only partially filled and was displaced forward, and in another patient (Case 15) the fourth ventricle was displaced upward.

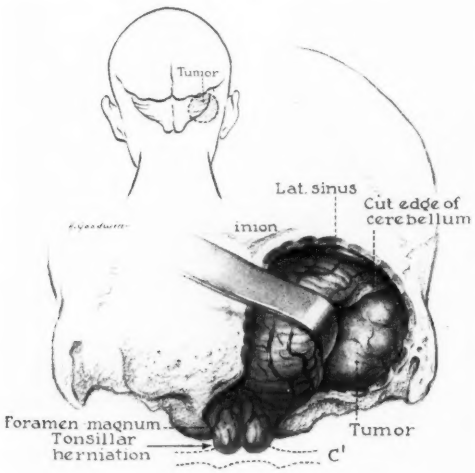

Fig. 5. Case 3. Appearance of tumor at operation.

Three of the patients in this series died without benefit of surgical exploration of the posterior fossa. Case 1 illustrates the minimal signs and symptoms—the absence of signs of increased intracranial pressure, the negative x-ray examination, and the normal cerebrospinal fluid which sometimes characterize these tumors. This patient died because of herniation of the cerebellar tonsils through the foramen magnum, undoubtedly aggravated by lumbar puncture. Another patient (Case 2) had symptoms and signs typical of a glioma of the brain stem, and the true disease was not suspected before autopsy. It seems likely that in the future we should advise all adults who present evidence of an expanding intramedullary lesion of the brain stem to have a suboccipital exploration. The third died of bronchopneumonia before surgery could be done.

In Case 11, though posterior fossa exploration was done, the tumor was not seen at operation, and the patient died 40 days later. Of the 11 patients in whom the tumor was partially or completely removed, only 4 are definitely known to be alive. These patients (Cases 5, 10, 14, and 15) have survived 8 years, 7 years, 5 months, and 3 months respectively. All are able to carry on household duties. One patient (Case 3) survived 3 years after removal of his tumor and was able to carry on heavy work during this period, but died during an exploration for recurrence of the meningioma. Another patient (Case 9) died 2 years after partial removal of her

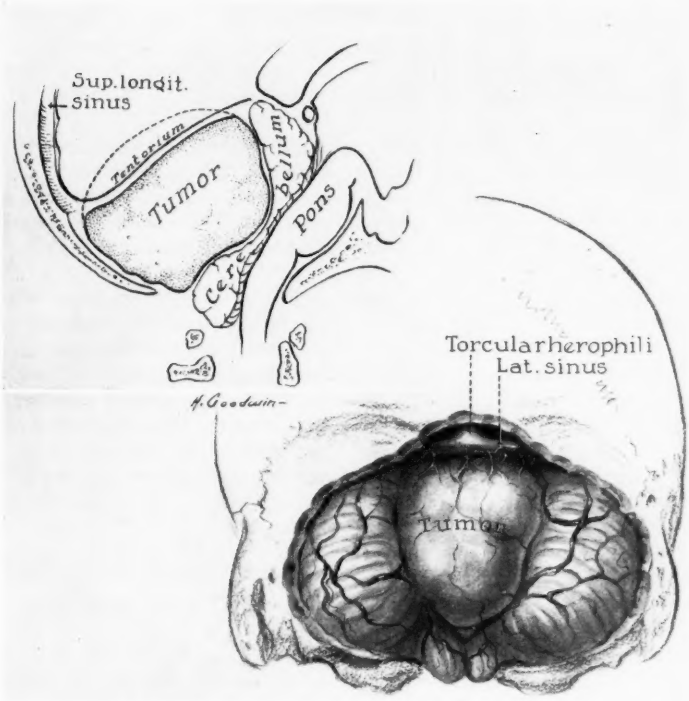

Fig. 6. Case 10. Appearance of tumor at operation.

meningioma and 6 months after a two stage removal of the recurrent growth. Two patients (Cases 6 and 12) survived 27 and 20 months postoperatively and then were lost track of. Cases 7, 8, and 13 died within a short time following removal of their meningiomas. Thus, the immediate operative mortality in cases in which resection of tumor was done is 27 per cent.

COMMENT

There are few intracranial tumors that offer as great difficulty in diagnosis as do the meningiomas of the posterior fossa. This difficulty is as much a matter of recognizing the presence of an intracranial tumor at all, as it is one of localization. Those patients who have papilledema or who present a group of clearcut symptoms, such as those of a lesion in the cerebellopontine angle, present no serious problem. However, those patients whose tumors arise in the extremity of the lateral recess or from the undersurface of the tentorium cerebelli, whose symptoms are largely those of headache, who show little or no objective findings, who have no demonstrable evidence of increased intracranial pressure either in their eyegrounds or on lumbar puncture, and who have normal spinal fluid and normal roentgenograms of the skull present a very serious problem. Unfortunately, there are no touchstones to which we can point as unfailing or even as significant criteria in such cases. The appropriate diagnosis will usually depend upon the keenness of the diagnostic acumen of the physician, his persistence and his refusal to relegate the patient to that large, unfortunate, and often forgotten group of patients loosely classified as psychoneurotic.

There is one point, however, which we should like to make. Whereas evidence of

progressive involvement of multiple cranial nerves and of the various fiber tracts in the brain stem in a child usually signifies the presence of a glioma of the pons, such is not the case in adults where such gliomas are much less common. In adults with such manifestations the possibility of a meningioma must be seriously entertained (Case 2). Furthermore, such symptoms are not necessarily indicative of a tumor directly involving the brain stem and the cranial nerves. The tumor may, as in this case (Figs. 3 and 4) arise from the undersurface of the tentorium and involve these structures only by indirect pressure.

Until recently even the existence of meningiomas of the posterior fossa has not been generally appreciated. This and other papers on the subject which have appeared recently serve principally to call attention to their frequency and to point out the protean nature of their manifestations.

SUMMARY

At least 10 per cent of meningiomas occur in the posterior fossa. The most common sites of origin are the cerebellopontine angle, the tentorium, the lateral recess, and the clivus. These tumors may extend above the tentorium or below the foramen magnum. They are frequently attached to large dural sinuses. This latter fact, together with the proximity of the tumor to brain stem and cranial nerves, leads to great difficulties in the surgical removal of many of the meningiomas of the posterior fossa. Though the immediate operative mortality is about 30 per cent, many long-term survivals are on record.

Clinical signs and symptoms of meningiomas of the posterior fossa may be very slow to appear. The signs and symptoms may mimic a wide variety of conditions, including trigeminal neuralgia, acoustic neurinoma, glioma of the brain stem, intrinsic cerebellar tumor, and basilar meningitis. Though headache is almost universal with meningiomas of the posterior fossa, papilledema is often absent. Cerebellar signs are often minimal, sometimes being confined to subjective unsteadiness of gait. Cranial nerve involvement may lead to any of a number of appropriate signs and symptoms. In a minority of cases x-ray examination of the skull gives evidence of the nature of the lesion. Ventriculography is of great aid in detecting the tumor. More recently angiographic evidence of the tumor's presence has been demonstrated in a few of the cases.

The case histories from the authors' series of 15 patients with meningioma of the posterior fossa illustrate the diagnostic and surgical difficulties so frequently encountered.

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THE PROGNOSIS IN CARCINOMA OF THE COLON PERFORATING INTO THE URINARY BLADDER

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THE general principles of resective cancer surgery, based on an intimate knowledge of the regional lymphatics and their removal in continuity along with the primary growth, are well recognized and have long been practiced. Yet, for some reason the matter of carcinomatous spread via direct extension, with involvement of tissues and organs adjacent to the primary site, has not received merited attention. Until recently this was particularly true of carcinomas of the colon and stomach which, by virtue of penetration, had become adherent to, or had perforated into, such structures as the small intestine, gallbladder, abdominal wall, urinary bladder, uterus, and vagina. Heretofore, such complications had influenced surgeons to perform short-circuiting or other palliative operations in the belief that the primary growths and their extensions were irremovable. Surgical pathologists consequently have had small opportunity to study the actual extent of such perforating growths, and necropsy pathologists viewing the end stages of the process did little to encourage more venturesome surgical attacks on the lesions.

In recent years Turner, Babcock, Gilchrist and David, Colby, and Schwartz and Bergman, to name a few, have pioneered surgical attacks on these extensive carcinomas, and Brunschwig with others has shown that resection of multiple organs can sometimes encompass growths which have "burst their bounds" so to speak. In our own clinic, Mayo and also Dixon and Olson have had similar experiences. It was with the idea of examining one small facet of the problem that we undertook a clinicopathologic study of colonic carcinomas which had perforated onto or into the urinary bladder.

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Abridgment of thesis submitted by Dr. Taylor to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

MATERIAL AND METHODS

Fifty-nine cases of carcinoma of the colon involving the bladder, encountered at the Mayo Clinic from 1907 through 1946, were studied. In all cases, a segment of the colon had been found at operation to be involved by carcinoma and to be attached to the bladder. Only when there was obvious gross attachment at a point of contact between the colon and the bladder was the case included for study; cases of remote involvement of the bladder by carcinomatous implants alone were not considered. Rectal growths were excluded because it was considered that invasion of structures other than the bladder would complicate the picture.

In 5 cases only biopsy material was available. In a sixth case in which the growth was not removed at operation the necropsy specimen and report combined with the operative record were used. In the remaining 53 cases adequate tissue removed from the colon and bladder at operation was available for direct study.

These 53 surgical specimens and 1 postmortem specimen, all carefully preserved in 10 per cent formalin, were examined in the following manner. The growth was measured and a sketch drawn showing how much of the circumference of the bowel was involved, in an effort to ascertain roughly the age of the carcinoma. If bladder tissue was attached, the relationship of this tissue to the colonic carcinoma was noted. Sections were cut through the carcinoma to study the grade of malignancy, and to ascertain the degree of mural penetration. Search was carefully made to determine the nature of the contact-attachment between the colon and bladder. In some of the 54 specimens a large piece of the full

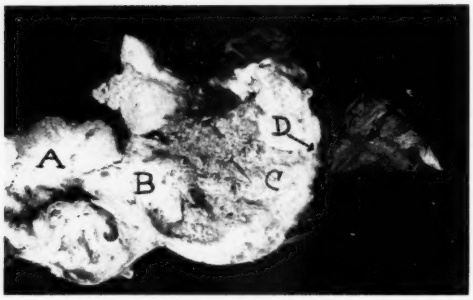

Fig. 1. Specimen of carcinoma of the colon with full thickness of vesical wall in cross section. *A* shows muscle of colon; *B* carcinoma; *C* bladder wall with muscle bundles. The arrow at *D* points to mucosa of the bladder.

thickness of the bladder wall was included (Fig. 1). In these, evidence of a vesicocolic fistula was sought for, and when one was found, sections were taken to determine whether or not the fistulous tract was lined by carcinoma cells. In those instances in which the bladder was attached, sections were taken through the point of attachment to the colon to determine the pathologic condition of the attachment and the depth of mural penetration by the carcinoma into the wall of the bladder. In some cases no bladder tissue was visible on gross examination, there being present only a region of roughening over the colon which suggested the point of attachment to the bladder. Sections were made through this roughened tissue, to be examined microscopically for bladder tissue.

Bladder tissue could often be differentiated from colonic wall by the gross picture of the bladder muscle (Fig. 1). The latter appears on cut surface as small spherical muscle bundles like the cut end of a wire cable. The colonic muscle appears grossly as distinct layers on section (Fig. 1*A*) and is without the dotted appearance of bladder muscle (Fig. 1*C*). This gross appearance of the cut surfaces of colonic muscle and bladder muscle corresponds with the microscopic appearance as is shown in Figures 2 and 3, respectively.

Lymph nodes were searched for with gross serial sections of the fat, especially in the mesentery of the colon and about the bladder tissue in 54 cases in which tissue was sufficient (53 surgical cases and 1 necropsy). An attempt was made to find at least 4 or 5 nodes in each case. All nodes found were sectioned for microscopic study.

Attention was focused also on all observed blood vessels for evidence of invasion, and if invasion was suspected grossly a section of the area was saved for microscopic examination.

Blocks of tissue, selected by the method described, were placed in carefully labelled bottles of fresh 10 per cent formalin. Sections were then prepared, using the frozen section technique, and stained routinely with hematoxylin and eosin. In all, many hundreds of slides were thus made available for microscopic study.

CLINICAL FINDINGS

From examination of the records of these cases the following findings were noted: The average age of the patients was 55.4 years, the oldest patient being 76 and the youngest 19 years of age. There were 48 males and 11 females in this group. This difference in sex is probably accounted for by the fact that in the female the uterus, tubes, ovaries, and broad ligaments offer a barrier to contact between the colon and bladder. All 59 patients had some symptoms pertaining to disturbances in the gastrointestinal tract or the urinary tract or both. Fifty per cent of the patients had complaints referable to the urinary tract and 10 patients gave a history of passing gas or feces through the urethra. Nothing else remarkable was noted concerning symptoms. Duration of symptoms varied from 2 weeks to 3 years, the average being 11.8 months in the 57 cases in which the information was recorded. The resectability rate was 89.8 per cent (53 of the 59 cases). In 1 case the growth was exteriorized, but the patient died before the growth was removed at a planned second stage. In 5 cases the operation consisted of a colostomy with removal of a specimen from the site of perforation. The operative mortality was 10.2 per cent as 6 of the 59 patients died in the hospital.

PATHOLOGIC FINDINGS

The pathologic findings will be described first in all cases in which there was inflammatory or carcinomatous attachment of the

Fig. 2. Wall of colon showing layered appearance of the muscle. Muscle bundles like those in the wall of the bladder shown in Figure 3 are absent. Hematoxylin and eosin, ×21.

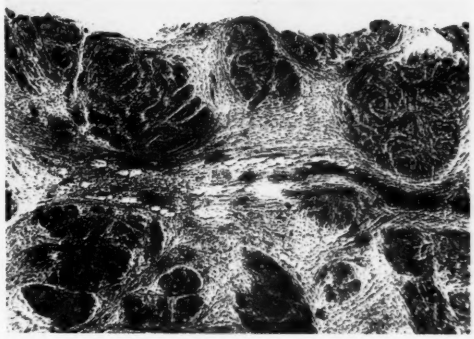

Fig. 3. Wall of bladder showing marked muscle bundles. This should be contrasted to wall of colon shown in Figure 2. Hematoxylin and eosin, ×21.

bladder to the carcinomatous segment of colon. Then we will consider the cases in which carcinoma was microscopically demonstrable in the bladder wall, that is, those in which the attachment between bladder and colon was definitely carcinomatous.

Polyps were found in 8 cases (13.6 per cent) either at proctoscopic examination or in the specimens. In 1 case about 30 polyps were seen in the rectum.

There were multiple carcinomas of the colon in 3 cases (5.1 per cent), exclusive of the cases in which the tips of polyps were involved by carcinoma. In 1 of these 3 cases, 2 carcinomas were found in the specimen removed. One patient had 2 simultaneous carcinomas, the one in the sigmoid was removed but the one in the rectum was not. The other patient had 3 carcinomas removed at different times. In 1926 a cecal lesion was removed, in 1936 a lesion in the descending colon, and in 1945 a lesion in the sigmoid. Death occurred from recurrence of the last carcinoma.

The carcinoma in all except 1 of these 59 cases was located between the descending colon and a point 15 centimeters above the anus. In the 1 exception the lesion was in the cecum.

The malignant lesions averaged 7 centimeters in one "diameter." To compute this figure the greatest distance between any two boundaries was measured on the gross specimen. For example, in a carcinoma partially encircling the bowel and measuring 1 centimeter thick, 3 centimeters up and down the lumen, and 7 centimeters about the circumference of the bowel, the largest figure, 7 centimeters, was used to obtain the average size.

The grade of malignancy (Broders' classification) was low in the vast majority of the 60 carcinomas examined in the 59 cases; 24 were of grade 1, 29 grade 2, 7 grade 3, and 0 grade 4.

Lymph nodes involved by carcinoma were found in 31 (57.4 per cent) of the 54 cases in which sufficient tissue was available to make search for nodes feasible. In 5 cases the presence or absence of nodal involvement could not be determined.

Invasion of the lumen of a vein was demonstrated microscopically in 1 case.

At operation in 3 cases (5.1 per cent) definite metastasis was found in the liver, and miscellaneous "nodules" were felt in 6 cases.

Attachment to organs other than the bladder had occurred in many of the 59 cases. The small intestine was involved in a total of 10 cases, the uterus in 4. In 1 case both were involved. The uterus or the small bowel or both were involved in 20 per cent of cases.

Certain observations were made concerning pathologic changes in the bladder and the attachment between colon and bladder. On gross examination of the preserved specimens, it was often impossible to define the limits of the carcinoma in the bladder. In most cases, too, it was difficult to tell whether the bladder was involved by carcinoma, but in some cases

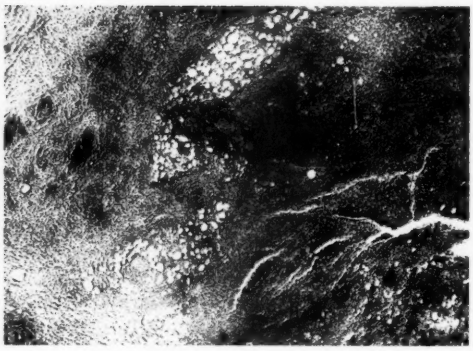

Fig. 4. Section at site of attachment between colon and bladder. Dark areas of leucocyte infiltration forming abscesses should be noted. Hematoxylin and eosin, ×21.

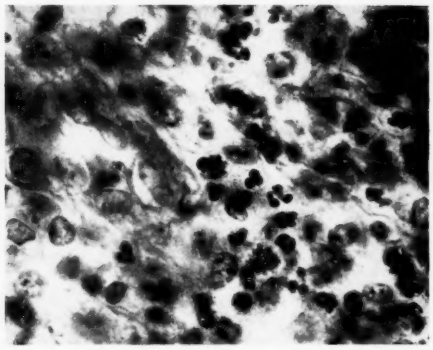

Fig. 5. Dark area shows details of abscess as in Figure 4. Under higher magnification one observes numerous polymorphonuclear leucocytes. Hematoxylin and eosin, ×595.

this could be seen in the gross specimen. In 4 specimens vesicocolic fistulas were demonstrable. No abscesses were noted in the preserved specimens although in some the friable material was suggestively purulent.

On microscopic examination there was usually little doubt as to the presence or absence of carcinoma in the bladder. Usually it was obvious at a glance. Abscesses (Figs. 4 and 5) were looked for and were found in 14 of the 59 cases (23.7 per cent). In 4 cases foreign body giant cells were present. In 1 case there was cystitis cystica (Fig. 6).

Microscopic evidence of carcinoma in the wall of the bladder was demonstrable in 20 (more than a third) of the cases in which bladder tissue was available for study. In these cases certain features indicated that the malignant lesions were further advanced than in the cases in which carcinoma could not be demonstrated in the wall of the bladder.

Nodes were positive for carcinoma in 17 (53.1 per cent) of 32 cases in which the bladder was not involved by carcinoma and in which nodes were available for study. They were "positive" in 14 of the 20 cases (70 per cent) in which the wall of the bladder was invaded by carcinoma. In the 3 cases in which the surgeon thought definite metastatic nodules were present in the liver the bladder wall was involved by carcinoma, whereas in the cases in which the wall of the bladder was not involved, the liver was not thought involved in any case either. The only case in which venous invasion was demonstrated was in the group in which the bladder was involved. The survival rates substantiate these findings as will be shown.

In 4 cases a vesicocolic fistula was present. In all 4 cases the fistula was lined by carcinoma which penetrated the lining of the bladder and the fistula was therefore not merely on an inflammatory basis (Figs. 7 and 8). The nodes were involved in all 4 cases. One patient was dead 11 months after operation, 1 was alive, but had a recurrence 11 months after operation, 1 having hepatic metastasis was alive when last heard from 6 weeks after operation, and 1 was alive 6 months after operation. Such fistulas, then, appear to be of serious import.

PROGNOSIS

The survival rates for the total group comprise all cases in which the colonic segment containing the carcinoma was attached to the bladder regardless of the actual invasion of the bladder wall by malignant cells. In Table I the survival rates are presented and show that the 3 year survival rate was 50 per cent and the 5 year survival rate was 33.3 per cent.

That those cases with the carcinoma demonstrable in the bladder wall carry a worse prognosis than those without demonstrable carcinoma in the wall is suggested again by a comparison of the 3 year survival in the two groups. Of the 36 cases eligible for a 3 year follow-up we traced 34. Of the 13 cases traced

with carcinoma in the bladder the 3 year survival rate was only 38.5 per cent, whereas in the 21 cases without carcinoma in the bladder this rate was 57.1 per cent.

COMMENT

The term "perforating carcinoma" of the colon, as used here, means that the carcinoma cells have penetrated through the muscle layers of the colon and invaded the visceral peritoneum. Inflammation accompanies this process and abscess formation either microscopic or gross is often found. Likewise adherence of the involved segment of colon to adjacent structures may take place.

Now in such fixation there is evidence that often the carcinoma has not spread beyond the local lesion. Sugarbaker has analyzed cases of carcinoma of the large intestine in which there was attachment to other organs. In those cases in which it was necessary to resect some other structure, he stated that the frequency of invasion of lymph nodes, veins, and nerves was higher than when additional structures were not removed. However, in 41 per cent of his cases in which resections of adjacent structures were performed, and in 9 of 20 cases in which actual invasion of the adjacent structures had already taken place, veins, lymph nodes, and nerves were not involved.

Perforation into the urinary bladder was signaled by symptoms referable to the urinary tract in about half the cases in the present study and also in the 10 cases studied by Colby. The passage of gas or feces or both through the urethra occurs not infrequently. These lesions are often removable, as is shown by a resectability rate of 89.8 per cent in this series and of 65.5 per cent in that of Dixon and Benson. The hospital operative mortality is not excessively high considering the extent of the carcinoma. In our cases it was 10.1 per cent.

The lesion is almost always in the sigmoid although very rarely the cecum may be the site of the carcinoma. Rectal carcinoma, like sigmoid carcinoma, involves the bladder not too infrequently. Schwartz and Bergman found adherence of the bladder to the sigmoid or rectum in 16 of the 125 cases of carcinoma of the colon and rectum.

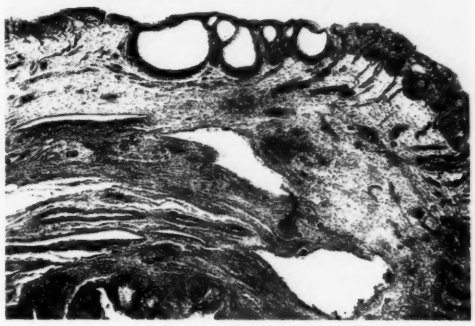

Fig. 6. Area of cystitis cystica. Carcinoma may be noted at bottom of photograph to the left of center. Hematoxylin and eosin, ×21.

Perforation into the bladder occurred in at least 1 per cent of the cases of carcinoma of the colon in which resection was performed at the clinic during the period under consideration. Colby found this incidence to be 7.5 per cent. Bargen and Larson found that 9.2 per cent of rectal malignant lesions had extended to the bladder.

Lymph nodes were involved in 57.4 per cent of the 54 cases in which such study was possible in our series. Lahey has reported cases of carcinoma of the colon involving the bladder without involvement of lymph nodes and Brunschwig, cases with involvement, but no such comprehensive study, as the present one, was found recorded. Demonstrable venous invasion in analogous cases was not reported in the literature. It was discovered in only 1 case in our study. Metastasis to the liver was demonstrated in 5 per cent of our cases.

TABLE I.—SURVIVAL RATES IN 59 CASES

Period, years	Patients*			Lived beyond indicated period, per cent of traced patients
	Total	Traced	Number	
1	36	34	28	82.4
2	36	34	24	70.6
3	36	34	17	50.0
4	27	24	8	33.3
5	19	18	6	33.3

*Inquiry as of January 1, 1948. Included in the 3 year group are those patients operated on 3 or more years prior to the time of inquiry, that is, 1944 or earlier; for the 4 year group 1943 and earlier and so forth. Hospital deaths are omitted from the calculations.

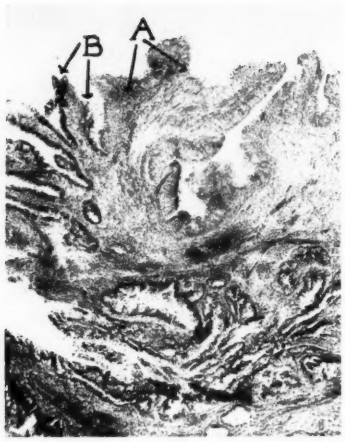

Fig. 7. Section through vesicocolic fistula. *A* indicates mucosa of bladder; *B* carcinoma encroaching on mucosa. See Figure 8 for higher magnification. Hematoxylin and eosin, ×21.

Local attachment of carcinoma of the colon to structures other than the bladder was reported by Dixon and Benson who found the uterus involved in 4 or 5 women and by Sugarbaker who also found the common iliac vein involved. In the present series the small bowel or the uterus or both were involved in 20 per cent.

The question of carcinomatous invasion of the bladder from the colon has been studied by others. Dixon and Benson found that the attachment between bladder and colon was carcinomatous in 21 of their 40 cases and only inflammatory in 19. Schwartz and Bergman could not find carcinoma in the bladder wall in any of their cases at post mortem. How many such cases were examined at necropsy was not stated. Colby found that the attachment of the colon to the bladder is often an inflammatory mass as in diverticulitis. Sugarbaker discovered malignant invasion of the bladder in 2 out of 3 cases.

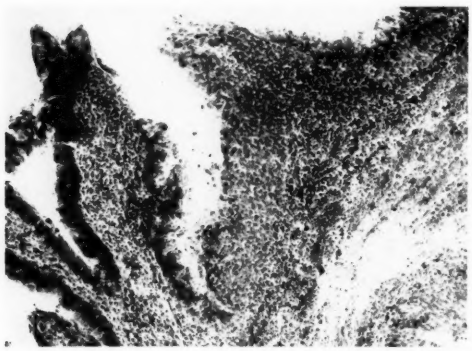

Fig. 8. Higher magnification of carcinoma adjacent to mucosa of bladder. Section through vesicocolic fistula shown in Figure 7. Hematoxylin and eosin, ×71.

Bargen and Larson found that the extension of the malignant lesions of the rectum to other organs was usually inflammatory and not malignant. In the present study the results are much like those of the others reviewed. In about a third of the total 59 cases the spread of malignant lesion to the wall of the bladder was demonstrated. Abscesses were demonstrated in about a fourth of the total group. Thus our experience and that of others show that in the majority of cases the attachment is inflammatory, not malignant.

The prognosis in cases of attachment of the carcinomatous lesion in the colon to the bladder has had little study. Survival times in sporadic cases have been reported. Survival for as long as 20 years has been reported by Dixon. The overall picture from the literature has given this group of cases a fair prognosis as far as carcinoma of the colon goes. Dixon and Benson reported survival of more than 5 years in 7 cases. The 5 year survival rate for the total 59 cases in this study, omitting hospital deaths, was 33.3 per cent.

SUMMARY AND CONCLUSIONS

All cases of carcinoma of the colon with direct attachment to the bladder in which operation was performed at the Mayo Clinic from 1907 through 1946 were studied. Cases of rectal carcinoma were not included. The literature pertaining to the prognosis when this attachment exists was reviewed. Urinary symptoms occur in about 50 per cent of cases with feces or gas being dramatically passed through the urethra in some. The resectability rate seems to be around 75 per cent if all available reports in the literature and this series are considered and the hospital mortality rate is not prohibitive, it being 10.1 per cent in the present series.

The sigmoid flexure was the segment of colon involved in virtually all cases. The pathologic changes in the region of contact between colon and bladder were carefully studied. Carcinoma was demonstrated in about a third of the cases in which the bladder was resected, and most of the points of attachment consisted merely of inflammatory reaction without malignant invasion of the bladder wall.

Lymph nodes were involved in 57.4 per cent of the total group of cases in which resection was performed, and this involvement jumped to 70 per cent in cases in which carcinoma was demonstrable in the bladder wall. Metastasis to the liver was thought to be present in 5.1 per cent of the cases and venous invasion was demonstrated in 1 case in our series.

The prognosis for survival in our series was fair as that for carcinoma of the colon goes, the 5 year survival rate being 33.3 per cent. The prognosis is worse if the attachment to the bladder is carcinomatous, for the 3 year survival rate in these cases was 38.5 per cent as opposed to 57.1 per cent in the cases without carcinoma demonstrable in the bladder wall.

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THE EFFECT OF ENDOCRINE SUBSTANCES (ACTH AND GROWTH HORMONE) ON EXPERIMENTAL FRACTURES

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THE role of adrenocorticotropic hormone (ACTH) in various disorders of reaction is currently the subject of intense investigation. Early experimental work with acid extracts of the anterior pituitary gland of cattle indicated that these extracts closed epiphyses prematurely (2) and promoted the healing of fractures (3). Because of this earlier work and recently accumulated knowledge of the action of adrenocorticotropic hormone, an experiment was designed to determine whether it would also promote the healing of fractures in experimental animals. At the same time it was also decided to determine what effect growth hormone and a combination of growth hormone and adrenocorticotropic hormone (ACTH) would have on the healing of fractures.

MATERIALS AND METHODS

One hundred and eighty male white mice of the standard laboratory Strong A strain, which varied from 4 to 6 weeks in age and from 20.5 to 33.0 grams in weight, were employed. The mice were fed the Rockland mouse feed and had water ad libitum. They were housed 5 to a cage under uniform laboratory conditions.

The mice were divided into 5 major groups (Table I). Group I was a control group in which no fractures were produced. This group was used mainly to study the weight of a normal group of mice and the strength of the tibia at various stages in the experiment. Group II was a control group in which the right tibia was fractured, but the mice received no treatment. Group III consisted of 40 mice who had the right tibia fractured, each of whom received 4 milligrams of ACTH daily intramuscularly in 4 divided doses. Group IV consisted of 40 mice who had the right tibia fractured and who received 50 gamma of growth hormone per mouse daily. Group V consisted of 40 mice who had the right tibia fractured and who received a combination of 2.0 milligrams of ACTH daily intramuscularly in 4 divided doses and 25 gamma of growth hormone daily.

Mice were sacrificed at 5 day intervals following fracture, so that the last mice were sacrificed 20 days after fracture.

On the first day the mice were lightly etherized and the right tibia of each broken approximately at the midshaft. Beginning the same day, the treated animals were injected intramuscularly with the drugs allotted to the various groups.

An earlier experiment demonstrated that the mice would not tolerate tape and wood splints and chewed them off by the third day. The fractures angulated, but since they were fairly uniform fractures, the angulation was also uniform.

On the day a group of animals was sacrificed, the following procedures were carried out. The animals were etherized and both hind legs were amputated at the midthigh region. The fractured amputated limbs were lined up on a nonscreen film and roentgenograms made. The tibia of each specimen was carefully stripped of soft tissue and the callus and tibia were exposed. The callus was measured across its greatest diameters anteroposteriorly and laterally. Half of the control specimens and half of the treated specimens were immediately placed in a solution of 10 per cent formalin for sectioning and histologic study. The remaining specimens were checked for character and strength of callus. This was done according to the method described by Straus. The strength of the left tibia of the mice of groups II, III, IV, and V, and the right tibia of the mice of group I was measured in this fashion also.

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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 1. Control specimen. Photomicrographs all × 2.
Fig. 2. Specimen treated with ACTH.
Fig. 3. Specimen treated with growth hormone.
Fig. 4. Specimen treated with a combination of growth hormone and ACTH.

Histologic sections were embedded in celloidin and stained with hematoxylin-eosin. They were cut a thickness of 10 to 15 micra.

RESULTS

Weight (Chart 1). All groups but group I showed a drop in weight at 5 days. This probably was a posttraumatic reaction. Later in the experiment, the mice treated with ACTH were better able to maintain their weight, perhaps an indication of the ability of the hormone to help the body withstand stress.

Size of callus (Table II). Callus in all groups became smaller as it matured, and in

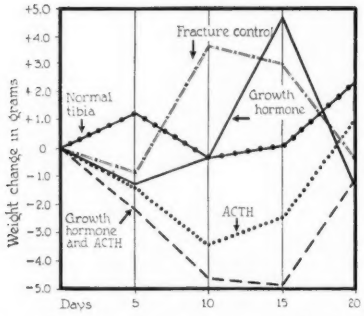

Chart 1. Weight changes in experimental animals.

all but group V the callus became rigid by the twentieth day.

Strength of callus (Chart 2). The strength of callus of the fractured control achieved a strength about that of the normal unfractured tibia. Of the treated groups, those treated with growth hormone produced a stronger callus than those treated with ACTH or a combination of ACTH and growth hormone. The ACTH-treated group had the weakest callus, indicating that the drug may interfere with the healing process.

Strength of the left tibia (Chart 3). The strength of the left tibia in the unfractured control group was about the same as in the right. The left tibia in the unfractured control group became weaker as the experiment

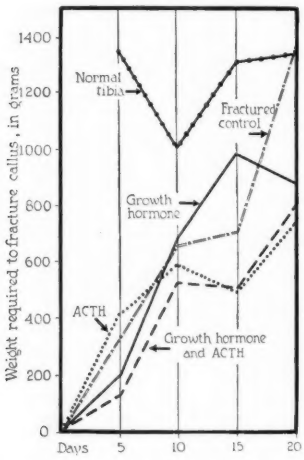

Chart 2. Healing of fractures in experimental animals.

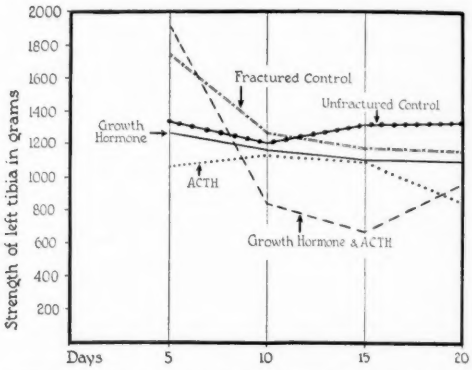

Chart 3. The strength of the left tibia in experimental animals.

progressed, but both control groups at 20 days had stronger tibias than in the treated groups. The strength of the left tibia in the treated groups paralleled at 20 days the strength of the callus, although they were somewhat stronger than the callus.

Mortality rate (Table III). There were no deaths in either control group. One death occurred in the growth hormone-treated group, a rate of 2 per cent. Eight mice died in the group treated with ACTH, or a mortality rate of 20 per cent. Five mice died in the group treated with a combination of ACTH and growth hormone, or a mortality rate of 10.2 per cent. This undoubtedly reflects the heavy dose of drugs used in the treatment.

Roentgenographic appearance. Roentgenologically the specimens were so small that no significant differences could be observed among the various groups.

Histologic picture. The specimens from groups sacrificed at 5, 10, and 15 day intervals revealed changes similar to those described at the 20 day period, but to a lesser degree. The description that follows is that of specimens from animals sacrificed 20 days after fracture.

With ACTH. The space between the shaft fragments is filled with callus, bone, and zones of fibrous connective tissue. Cartilaginous callus is present in various stages of maturity in moderate amount. New bone present is relatively immature as compared to the control. The cellular elements are much less mature with many of the new spaces filled

TABLE I.—PLAN OF THE EXPERIMENT

Group	No. of mice	Procedure	Mice sacrificed Interval of days				No. studied histologically	No. studied for callus strength	Unfractured tibia studied for strength
			5	10	15	20			
I Control	20	Tibias not fractured	5	5	5	5	0	0	20
II Control	40	Tibias fractured	10	10	10	10	20	20	40
III	40	Treated with ACTH (4 mgms. per mouse daily in divided doses)	10	10	10	10	20	20	40
IV	40	Treated with growth hormone (50 gamma daily)	10	10	10	10	20	20	40
V	40	Treated with a combination of ACTH (2 mgms. daily in divided doses) and growth hormone (25 gamma daily)	10	10	10	10	20	20	40

TABLE II.—AVERAGE SIZE OF CALLUS (mm.)*

Group	Time of sacrifice			
	5 days	10 days	15 days	20 days
I Unfractured control				
II Fractured control	18.3	21.6	20.6	19.6
III ACTH	15.3	18.7	18.9	15.1
IV G	18.3	21.0	20.0	15.6
V ACTH and G	16.8	21.0	17.7	17.5

*Product of greatest diameters, anteroposterior and lateral.

TABLE III.—MORTALITY RATE

Group	Deaths No.	Rate per cent
I Control (not fractured)	0	0
II Control (right tibia fractured)	0	0
III Group treated with ACTH—4 mgms., daily in divided doses	8	20.0
IV Group treated with growth hormone, 50 gamma daily	1	2.0
V Group treated with ACTH (2 mgms. daily in divided doses) and growth hormone (25 gamma daily)	5	10.2

with red blood cells. There is definite lag of red marrow development compared to the control. There is definite depression of endochondral ossification at the epiphysial line. There is diminution of collonading and normal reaction as compared to the control. The cells are clumped together.

With growth hormone. The space between the shaft fragments is filled with a large mass of new trabecular bone. A very slight amount of unreplaced callus is present. The bone marrow is vascular. The epiphysial line is wider than that found in the control. There is good collonading. The individual cells are large.

With ACTH and growth hormone. The space between the fracture fragments demonstrates a moderate proliferation of new trabecular bone. This mass is not confluent but appears to consist of two separate ossification zones, each arising from its own fracture fragment. A definite pseudomembrane of fibrous tissue separates the ossification zones, indicating a pseudarthrosis. In each zone there is a large area of unreplaced callus. The bone marrow is vascular; the epiphysial line is irregular and narrowed. The cartilage cells are small and inactive. There is a depression of collonading. There is a depression of growth activity as compared to the specimens treated with growth hormone and the control specimens. The histologic findings of the epiphysial region are similar to those described by Li and Evans in 1947.

CONCLUSIONS

Under the conditions of this experiment it appears that:

1. Adrenocorticotropic hormone (ACTH) inhibits formation and maturation of callus. It appears to inhibit the healing of fractures. It prematurely closes epiphyses.

2. Growth hormone does not interfere with callus formation but does not speed its maturation. It widens the epiphysial line and promotes greater growth.

3. A combination of adrenocorticotropic hormone (ACTH) and growth hormone inhibits the healing of fractures and may promote

the formation of a pseudarthrosis. It also has a tendency to produce irregularity in the epiphysial line.

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FRACTURE SEPARATION OF THE UPPER HUMERAL EPIPHYSIS

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NEW ideas are not common. It is often found that an effective treatment believed to present new features is almost identical with one already described. Thus, the method of treatment evolved for the injury under consideration was found to be similar to that detailed by Royal Whitman in 1908. Whitman's contribution appears now to be little known; it is hoped to show in the following that it deserves re-emphasis.

Separation of the upper humeral epiphysis with or without associated diaphysial fracture is not common, but it is well recognized. Generally such separations have been found difficult to reduce accurately by manipulation. Occasionally, in our experience, good manipulative reductions have been followed by immobilization in an incorrect position with resulting recurrence of deformity. As the late results of imperfect reductions are usually found to be satisfactory, serious attempts at closed reduction are often not made.

This paper represents a survey of 28 patients treated at the Birmingham Accident Hospital; 19 were males and 9 females. Their ages varied from 3 to 18 years; 23 of the patients were between 13 and 18 years of age. It was found that the injuries could be divided into 2 distinct types differing in pathological anatomy and treatment.

EPIPHYSIAL SEPARATION WITHOUT DIAPHYSIAL FRACTURE (3 CASES)

In this injury the epiphysis separates from the diaphysis at the epiphysial line without associated diaphysial fracture (Figs. 1 and 2). The manner in which the conical upper end of the humeral diaphysis projects into its epiphysis suggested that once any displacement was reduced it would not easily recur. This was substantiated in all 3 cases treated.

Mr. Jeffery was formerly of the Birmingham Accident Hospital, England.

In 2 cases reduction was achieved by traction in abduction; in the other case open reduction was required. The arm was immobilized by the side in all 3 cases for a period of 3 weeks, after which time shoulder movements were begun. A good reduction was obtained and held in each instance and restoration of function was rapid and complete. Premature fusion of the epiphysis followed, but no other abnormality was found at the time of review. The cases were reviewed at 4 months, 3 years, and 4 years respectively.

EPIPHYSIAL SEPARATIONS WITH DIAPHYSIAL FRACTURE (25 CASES)

In this more common type of injury the epiphysis separates from the diaphysis anterolaterally at the epiphysial line. Posteromedially a wedge of bone fractured from the shaft remains attached to the humeral head (Fig. 3).

Clinical features. Usually when first seen the patient has the arm in a sling. Signs of a bone injury at the upper end of the humerus are present, the outstanding feature being a well marked abnormal bony prominence beneath the anterior deltoid fibers. Satisfactory x-ray films can be taken without moving the arm, the lateral exposure being made through the body. An anteroposterior film will generally show only foreshortening of the humeral neck or very slight angulation. The lateral view reveals a fracture separation of the upper humeral epiphysis, a variable degree of backward angulation, and upward displacement of the shaft; the triangular diaphysial fragment remaining attached to the capital epiphysis is shown posteriorly. In more severe cases there is complete displacement of the capital element from the shaft (Fig. 11).

With the arm in a sling, the humerus is internally rotated from the "anatomical position" so that the triangular diaphysial fragment shown posteriorly in the x-ray film is in

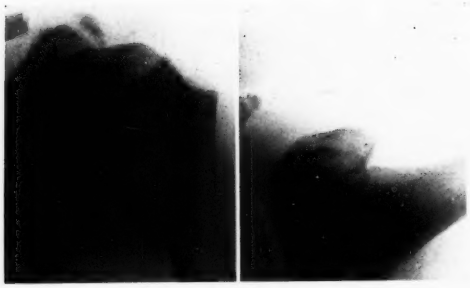

Fig. 1. Epiphysial separation without diaphysial fracture.

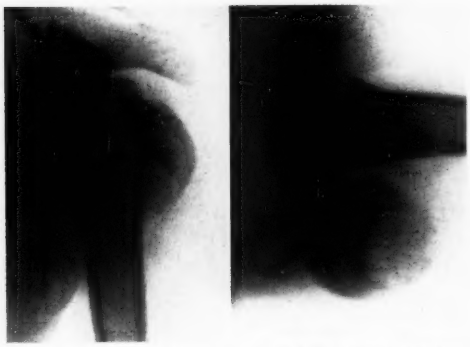

Fig. 2. Epiphysial separation without diaphysial fracture with complete displacement of the head.

Fig. 3. Epiphysial separation with diaphysial fracture.

fact situated posteromedially; similarly the apparent backward angulation is in reality backward and inward. This has been established by a careful study of the roentgenograms of a number of cases and by the pathological anatomy demonstrated at operation.

Fig. 4. Illustration of position of falling. Insets show mechanism of displacement.

In no case in this comparatively large series was the epiphysis displaced laterally with an associated fracture of the lateral aspect of the shaft, as seen by Aitken in 5 of 11 cases.

The roentgenographic appearances, together with the observation that angulation is increased by backward or inward movements of the arm, suggest that the soft tissues around the bone are damaged in the front and on the outer side and also that they are probably intact posteromedially. This inference has been confirmed at operation when it is seen that the upper end of the humeral shaft has been forced through the periosteum anterolaterally and has buried itself in the deltoid

Mechanism of causation. We believe that the injury is caused by the patient falling backward onto the outstretched hand, with the shoulder extended, adducted, and internally rotated from the "anatomical position" so that the humerus lies in a neutral position midway between full internal and full external rotation. This is virtually the same rotational position as that of the humerus when the arm is suspended in a sling. A longitudinal compression force is thus exerted on the humerus causing fracture with backward angulation (Fig. 4). This view is confirmed by the maneuver required for reduction—to

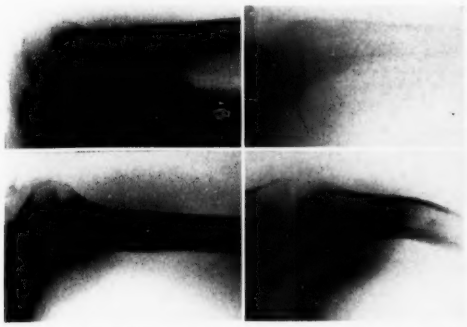

Fig. 5. Roentgenograms of patient, aged 16, at an early phase of union and 6 years later, showing persisting angulation.

Fig. 6. Roentgenograms of patient, aged 9, at an early phase of union and at 1 and 4 years later. The deformity has been completely corrected by remodeling.

Fig. 7. Photograph of position used for immobilization. Abduction by more than 135 degrees. Thirty degrees of forward inclination, maintained by pillow. Neutral rotation of shoulder.

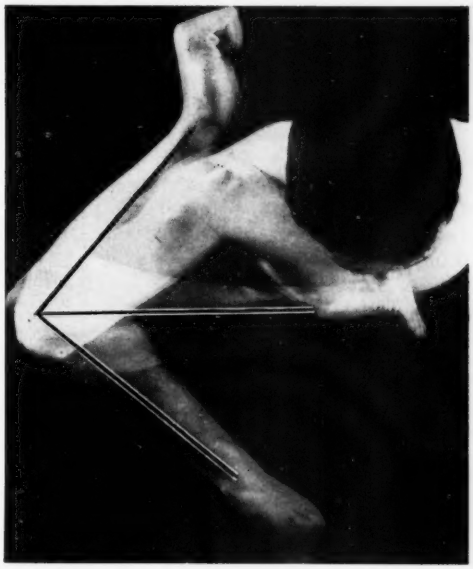

Fig. 8. Photograph taken from above showing full range of rotation at shoulder joint when arm is abducted by 135 degrees and inclined forward by 30 degrees.

be described in detail later—when the arm is flexed and abducted by not less than 135 degrees.

From the foregoing it will be seen that although we believe that the injury takes place in a particular rotational position we do not believe that it results from rotational violence. In this way our view does not coincide with that of Bourdillon who regards external rotation as a causative factor.

Review of cases. Between 1944 and 1949, twenty cases of this type were treated by

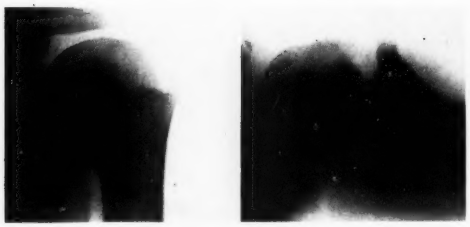

Fig. 9. A typical example of epiphysial separation with diaphysial fracture in patient, aged 14 years.

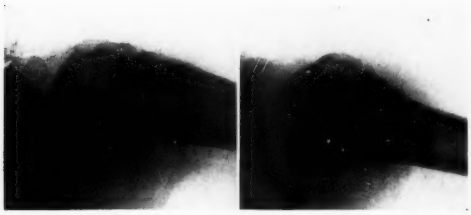

Fig. 10. Same patient as Figure 9, 3 months later. Treated by the method indicated in the text.

Fig. 11. Epiphysial separation with diaphysial fracture and complete displacement of head in patient, aged 3.

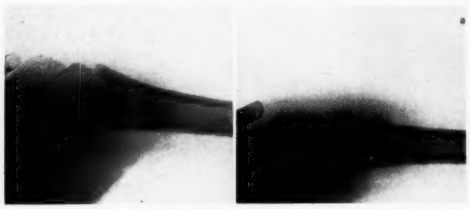

Fig. 12. Same patient as Figure 11, 3 months after treatment by the method described.

closed methods which included: (1) manipulation followed by traction or immobilization in abduction, but not above right angled abduction, (2) manipulation followed by traction in right angled forward flexion, and (3) manipulation followed by immobilization in adduction.

In 6 patients, so poor was the position obtained, that open reduction was performed. In 7 others union occurred with displacement and at least 30 degrees' angulation. Fair but incomplete reduction was achieved in 3 patients while in another 3, including the 2 with least deformity, good positions were obtained and held. In the remaining case union with the original deformity—25 degrees of angulation—was allowed.

Reviews were carried out at periods varying from 1 to 6 years after injury.

FINDINGS

Full function was present in all but 3 cases. Of these 1 had been treated by operation and had a little restriction of internal rotation. The cases of the other 2 patients, who had been treated by closed methods, were reviewed at 1 and 4 years respectively. Neither was able to elevate the arm completely, each failing to do so by some 30 degrees. In both, the fracture had united with displacement and gross angulation.

Roentgenographically there was no example of distortion of the humeral head. This may be due to the fact that there had been no epiphysial crushing, as suggested by Aitken. Further the epiphysis, even when displaced completely from the shaft, has abundant soft tissue attachments—capsule and rotator cuff—diminishing the risk of avascular necrosis. In this respect it is in contrast with the upper radial epiphysis. It was found, however, that when both shoulders were x-rayed there was evidence that the epiphysis of the injured shoulder fused earlier.

Angulation present at the time of union tended to diminish slowly and in some instances was appreciable as late as 6 years after injury, when as a result of growth the apex of the angle had been found as much as 2½ inches below the epiphysial line (Fig. 5.). In some younger children correction of the deformity was complete (Fig. 6). The bony step resulting from failure of reduction usually disappeared completely. Any residual angulation was so well masked by muscular development that it was hardly appreciable clinically.

Treatment of more recent cases. In December 1949 a further fracture separation of the upper humeral epiphysis was seen, and it was decided to attempt manipulative reduction. This was easily achieved under general anesthesia by traction on the upper limb in a position of hyperabduction—abduction to at least 135 degrees—30 degrees' forward inclination, and neutral rotation, accompanied by pressure on the bony prominence of the displaced upper end of the shaft. Reduction was lost as soon as the arm was brought down even to right angle abduction. Therefore, after remanipulation the limb was immobilized in the position already described (Figs. 7 and 8). The intact soft tissues on the medial and posterior aspects were thus placed in a state of tension so as to maintain reduction and at the same time to allow the torn soft tissues on the anterolateral aspect to fall together. A neutral position of rotation was used as the rotator muscles which remain attached to the upper fragment are approximately equally balanced. Skin extension and light traction over a suitably placed pulley were used to maintain reduction. After 3 weeks' immobilization shoulder exercises were started. The same method of treatment was subsequently employed in 4 other patients. In all 5 patients good reduction was obtained and held, union was rapid, and full function restored within 3 months (Figs. 9, 10, 11, and 12). There were no complications; above all at no time was there any evidence of traction injury to the brachial plexus.

After a thorough search of the literature it was found that this method of obtaining reduction had been described in detail by Royal Whitman as long ago as 1908. Unfortunately, it seems to have been little used up to the present, and we believe that it could, with advantage, be more widely practiced. After manipulation Whitman placed his patients in a plaster spica with the shoulder in a position similar to the one which has already been described.

Boehler and Bourdillon have also recommended similar methods of reduction. Bourdillon stresses the importance of medial rotation both in reduction and immobilization. We could find no reason for medial rotation as the reduction was stable in neutral rotation. Boehler does not immobilize the arm above right angled abduction.

CONCLUSION

Patients with separations of the upper humeral epiphysis, with slight or moderate angulation and incomplete displacement, can be expected to regain full function and to have no apparent deformity even without specific treatment. This does not apply to those in the upper age range, with severe deformity, nor to those with complete displacement of head from shaft.

It is recommended that manipulative reduction and immobilization as described—or in a plaster spica in a similar position—should be practiced. Under these circumstances full reduction, with resulting union and restoration of function with minimal delay, can be anticipated. It is thought that, at any rate in recent cases, open reduction should seldom be required.

SUMMARY

1. Two types of separation of the upper humeral epiphysis are described.

2. The mechanism of causation of the more common type is discussed.

3. The method of treatment now used successfully for this injury is detailed.

4. Twenty-eight cases are reviewed.

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A NEW TECHNIQUE FOR THE DIAGNOSIS OF CARCINOMA METASTATIC TO THE LIVER

A Preliminary Report

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IT is the purpose of this study to describe a new technique which employs abdominal radioactivity surveys for the detection of carcinoma metastatic to the liver. The need for an accurate and reliable method for the detection of liver involvement by metastatic neoplasms is apparent. According to Satterlee, the liver is the seat of blood borne metastases in 36 per cent of all cases of cancer, 44 per cent of all cases of gastric carcinoma, 50 per cent of all cases of carcinoma originating in portal areas, and 48 per cent of all cases of breast cancer.

The various liver function tests and needle biopsy of the liver are the only laboratory tests currently available to the clinician. These methods are unreliable, however, when dealing with early or solitary hepatic metastases. Many instances are recorded in which the liver function tests and biopsy have revealed little or no impairment in the face of obvious disease.

Recently the widespread employment of radical surgical procedures in the treatment of cancer has emphasized that the unsuspected or undetected presence of hepatic metastases is one of the chief causes for the failure of these procedures.

The new technique described in this report involves the use of radioactive iodinated human serum albumin (I*HSA) as the tracer material and the scintillation counter as the detector of the gamma radiation from the I^{131}.

METHOD

The wide angle scintillation counter (1) is used as the detector of the gamma radiation from the I*HSA. However, for this application the counter has been modified by the addition of 3 centimeters of lead around the bottom of the tube except for a ¾ inch aperture and an additional centimeter of lead around the sides. This additional lead shielding minimizes the background gamma radiation from parts of the body other than that under survey. It also provides collimation so that the incident angle for the radiation is limited to approximately 30 degrees. This additional shielding is essential for the success of the technique.

Each patient is given a single sterile intravenous injection of 300 microcuries of I*HSA. Twenty-four hours after the injection the patient is placed in a supine position upon an ordinary examining table, and a careful abdominal examination is performed to determine the anatomic location of the costal margins, xiphoid process, liver edge, and any palpable masses or organs. These relationships are plotted on a simple anatomic sketch (Fig. 1). For the abdominal survey the xiphoid process is used as a reference point, and its position marked on the patient's skin with ink. A guide is placed over this point and co-ordinate rectolinear points are marked at intervals of 5 centimeters from the nipple line to the intercristal line and from flank to flank (Fig. 2). A total of 42 positions are marked and the guide removed.

Successive counts are taken with the ¾ inch aperture of the scintillation counter placed flush with the skin over each point and perpendicular to the long axis of the body (Fig. 3). A sufficient number of counts are taken at each point to insure a counting error of less than ±3 per cent. The entire survey can be completed in 30 minutes.

From previous experience (4) we have found that the optimal interval between injec-

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tion and survey is 24 hours. However, the survey may be carried out up to 72 hours. It has been shown elsewhere that about 5 per cent of the radioactive iodine contained in the I*HSA may be absorbed by the thyroid gland. In order to prevent assimilation of this iodine and to preclude an untoward effect upon thyroid function, 0.5 cubic centimeter of potassium iodide as Lugol's solution is administered 3 times a day for 24 hours prior to the survey and 6 days thereafter. Sodium iodide may be administered intravenously in those cases in which oral administration is contraindicated.

This abdominal radioactivity survey was carried out in a total of 56 patients. Only 2 patients in the series were women. This small number is due to the preponderantly male population in a veterans' hospital. The largest group of patients were in the fourth and fifth decades of life, but the age range was from 23 to 77 years. All of the patients were selected from either the medical or the surgical services of the Wadsworth Hospital.

RESULTS

The 56 patients in this series are divided into the following four categories:

Group I, controls. Initially the survey was performed on a series of 10 carefully selected patients. A complete history, careful physical examination, and all the standard liver function tests were first obtained in order to exclude liver disease or other complicating systemic disease. Abdominal radioactivity surveys were then carried out in the manner described.

In order to compare the observed counts for the 10 patients, the X position on the 1–2 line, which corresponds to the tip of the xiphoid process, was arbitrarily chosen to represent 100, and the radioactivity values in terms of counts per second at each of the remaining points were then expressed as a percentage of the count observed at the xiphoid position. The mean and standard deviation for these percentages were then determined for each of the co-ordinate points. The standard deviation for each point was then multiplied by a factor of 1.5 to obtain a percentage range for the control group. The factor of 1.5 was used so that the probability of a normal individual exceeding these values would be expected to be only 1 in 10. The control range for each point is shown in Table I.

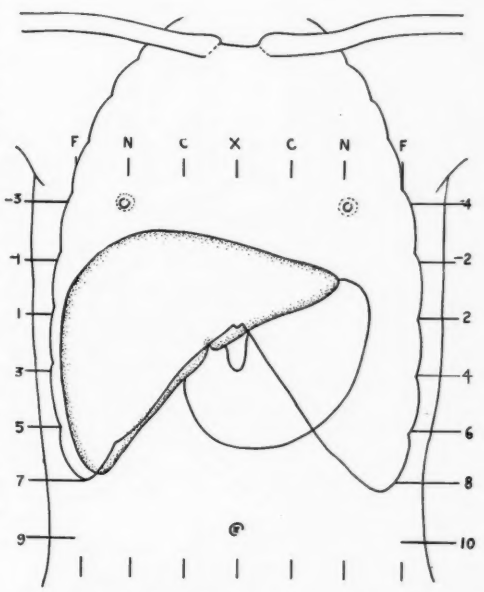

Fig. 1. A simple anatomic sketch representing the relationships of the liver, costal margins, and xiphoid process to the rectolinear co-ordinates used in survey.

Group II, primary neoplasm without hepatic metastases. This group comprises a total of 24

TABLE I.—CONTROL RANGES AT EACH OF CO-ORDINATE POINTS

	F	N	C	X	C	N	F
−3	43±10 (33–53)	66±27 (39–93)	96±21 (75–117)	129±20 (109–149)	119±27 (92–146)	79±24 (55–103)	48±9 (39–57)
−1	47±21 (26–68)	69±30 (39–99)	89±21 (68–110)	117±24 (93–141)	111±27 (84–138)	74±20 (54–94)	46±9 (37–55)
1	53±29 (24–82)	77±20 (57–97)	90±14 (76–104)	◎	93±15 (78–108)	73±18 (55–91)	50±17 (33–67)
3	47±18 (29–65)	67±14 (53–81)	78±14 (64–92)	89±12 (77–101)	86±21 (65–107)	69±21 (48–90)	46±14 (32–60)
5	37±21 (16–58)	55±17 (38–72)	67±14 (53–81)	75±15 (60–90)	73±17 (56–90)	63±15 (48–78)	42±11 (31–53)
7	39±17 (22–56)	55±14 (41–69)	63±15 (48–78)	71±15 (56–86)	63±15 (48–78)	55±11 (44–66)	39±8 (31–47)

These values represent 1.5 times the standard deviation of the observed radioactivity values at each of the co-ordinate points, expressed as a percentage of the value at the xiphoid position.

Probability: only 1 out of 10 times will normal be expected to exceed this figure.

Fig. 2. The rectolinear co-ordinate points are marked on the patient's skin with ink at intervals of 5 centimeters.

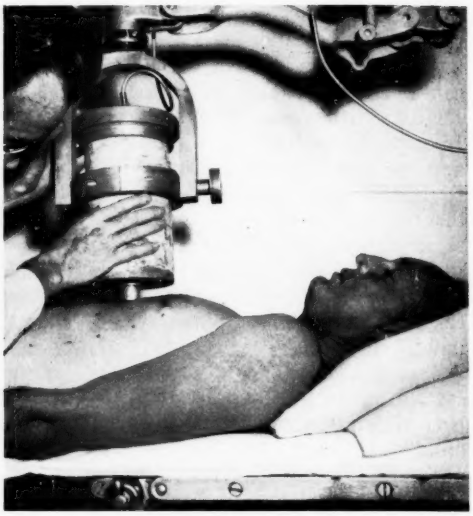

Fig. 3. The scintillation counter shown in position. Note that aperture of counter is maintained perpendicular to long axis of body and flush with patient's skin.

patients with verified intra-abdominal neoplasm and without palpable or visible hepatic metastases. The anatomic location and histopathology of the primary lesions are shown in Table II. The abdominal radioactivity survey in every case was within the normal range that was determined in the control group (Table I). Five of the patients in this group came to autopsy and careful serial sections of the liver confirmed the absence of neoplastic involvement. In the remaining cases liver biopsies were obtained at operation and in each instance revealed normal hepatic parenchyma.

TABLE II.—GROUP II, PRIMARY NEOPLASMS WITHOUT HEPATIC METASTASES IN 24 PATIENTS

Anatomical location	No.	Histopathology	No.
Rectum	5	Adenocarcinoma	5
Rectosigmoid	3	Adenocarcinoma	3
Stomach	6	Adenocarcinoma	4
Hepatic ducts	1	Leiomyosarcoma	2
Retroperitoneal	1	Papillary adenocarcinoma	1
Intraperitoneal	2	Lymphosarcoma	1
Pelvis	1	Malignant melanoma	2
Pancreas	1	Fibromyxosarcoma	1
Transverse colon	1	Adenocarcinoma	1
Sigmoid	3	Adenocarcinoma	1
Operative confirmation 100 per cent		Adenocarcinoma	3

Group III, primary neoplasms with hepatic metastases. Twelve (33 per cent) of the 36 patients with confirmed neoplasm had grossly demonstrable liver metastases at the time of laparotomy, and these were subsequently confirmed by microscopic examination of biopsy. The various sites and histopathology of the primary lesions are listed in Table III. Abdominal radioactivity surveys before operation were abnormal in each of these patients in that they exceeded the range determined in the control group. The case summaries show the characteristic clinical pictures seen and radioactivity patterns obtained in this group.

CASE 1. E. J. A., a 23 year old white male, entered the hospital with a 7 months' history of abdominal pain and loss of weight. There was no history of chills, fever, or jaundice. Physical examination revealed an enlarged liver palpable 3 fingerbreadths below the costal margin. The liver edge was smooth, regular, and not tender. No nodules or masses could be palpated. Carcinoma of the head of the pancreas with extensive hepatic metastases was found at operation.

The abnormal radioactivity pattern observed prior to operation is shown in Figure 4. Areas not shaded were within the control range.

CASE 2. R. W., a 39 year old white male, entered the hospital with a 4 months' history of weakness,

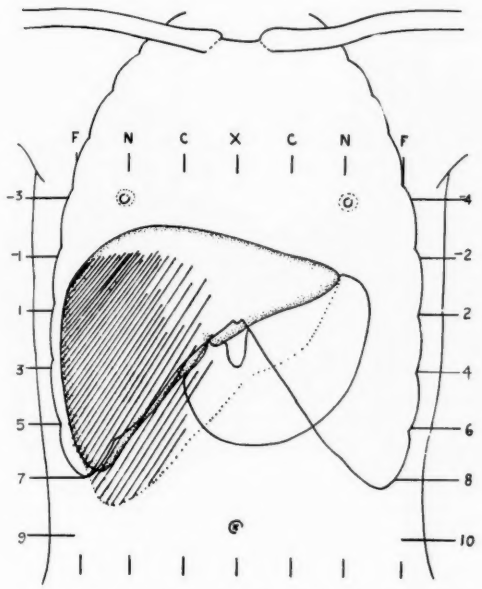

Fig. 4. Case 1. E. J. A. The shaded portion represents the area of abnormal radioactivity detected by the survey. The dotted line represents the enlarged liver, palpated below the costal margin.

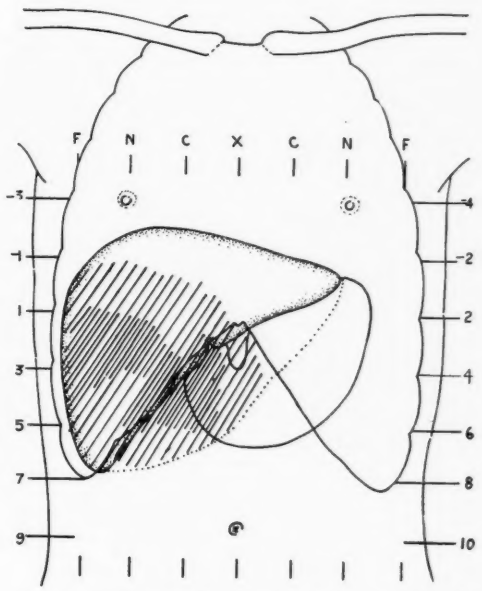

Fig. 5. Case 2. R. W. The shaded area represents the area of abnormal radioactivity detected by the survey. Note the dotted line representing the liver edge palpated below the costal margin.

anorexia, and moderate loss of weight. Physical examination revealed the liver edge to be palpable 4 fingerbreadths below the costal margin without palpable nodules. At the time of laparotomy a large carcinoma of the sigmoid colon with extensive hepatic metastases was found.

The abnormal radioactivity pattern observed prior to operation is shown in Figure 5.

Group IV, patients suspected of having neoplasm. Ten patients suspected prior to laparotomy of harboring neoplasms were subsequently found to have various benign lesions. The radioactivity surveys were normal in 8 cases and abnormal in 2 cases. In each of the latter 2 cases, large benign gastric ulcers were demonstrated.

DISCUSSION

Although this series of 56 patients is small, certain preliminary remarks are warranted.

Thomas and Zimmerman have recently emphasized the shortcomings of the use of liver function tests to detect the presence of metastatic carcinoma of the liver. This report is in agreement with the general observations of other workers who have shown that these tests are inconsistent in the presence of metastases to the liver. Our experience in this series corroborates their findings, in that the liver function tests were abnormal in only 40 per cent of the patients who were proved to have primary neoplasm with hepatic metastases. Of greater importance is the fact that the changes observed by these standard methods were nonspecific, and in many instances only a single test in the liver panel reflected any de-

TABLE III.—GROUP III, PRIMARY NEOPLASMS WITH HEPATIC METASTASES IN 12 PATIENTS

Anatomical location	No.	Histopathology	No.
Stomach	2	Adenocarcinoma	1
Pancreas	1	Leiomyosarcoma	1
Rectosigmoid	3	Adenocarcinoma	1
Nasopharynx	1	Adenocarcinoma	3
Retroperitoneal	1	Transitional cell carcinoma	1
Unknown	2	Reticulum cell sarcoma	1
Thyroid	1	Undifferentiated carcinoma	2
Skin	1	Adenocarcinoma	1
Confirmation 100 per cent		Malignant melanoma	1

gree of abnormality. Certainly no characteristic pattern which could be interpreted as characteristic of metastases was observed. On the other hand, not a single false positive or false negative result was obtained by radioactivity survey in either the group with liver metastases or the group without them. This is particularly significant when one considers that several patients in the group without metastases to the liver exhibited various degrees of hepatomegaly and/or jaundice without corresponding abnormality of the liver function tests It would seem, therefore, that not only is the radioactivity survey a more reliable method of detecting the presence of hepatic metastases, but in this series its accuracy was not affected by the presence of jaundice or hepatomegaly of benign origin.

Liver biopsy by means of an aspirating needle is also limited both in scope and reliability for the detection of hepatic metastases. As the liver is often asymmetrically seeded with metastases, the aspirating needle may enter a normal area and thus yield a false negative diagnosis. This method also carries with it a danger of producing intraperitoneal hemorrhage or biliary peritonitis. The latter complication occurs with such frequency in the presence of jaundice that it is felt by many clinicians that aspiration biopsy is contraindicated in the face of icterus. The radioactivity survey, however, can be performed with complete safety in the presence of jaundice. The speed, ease of performance, and the immediate availability of the results are distinct added advantages of the radioactivity survey.

The surveys in 2 of the 10 patients in the group suspected of having neoplasm were falsely interpreted as indicative of hepatic metastases. In each of the patients the foci of increased radioactivity were limited to the area of a large benign gastric ulcer. It is felt that in both of these instances the results were probably due to the increased uptake of I*HSA in the ulcer area and the error was due to misinterpretation of the significance of these increased foci. Further investigation has been undertaken in an attempt to localize primary lesions within the abdominal cavity. The preliminary results seem to bear out this contention. A report of this work is in preparation.

The evaluation of the reliability of this technique ultimately rests upon more widespread clinical trials.

SUMMARY

1. A new technique for the detection of neoplasm metastatic to the liver has been presented.

2. Abdominal radioactivity surveys are employed using I*HSA as the tracer material and the scintillation counter as the detector of the gamma radiation.

3. Fifty-six patients were studied by this method and the findings were correlated with those of conventional liver function tests and the operative findings.

4. An overall diagnostic accuracy of 96 per cent was obtained in this preliminary series.

5. The test is comparatively simple, rapid, and safe.

6. Final evaluation of the reliability of this new method rests upon more widespread clinical trials.

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CONGENITAL ATRESIA OF THE EXTRAHEPATIC BILE DUCTS

Report of 31 Proved Cases

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CONGENITAL atresia of the extrahepatic bile ducts is the commonest cause of obstructive neonatal jaundice. Although neonatal jaundice nd the passage of acholic stools may be sug-estive, the diagnosis of extrahepatic biliary tresia can only be made by exploration of he extrahepatic biliary system. Further-nore, this is the only means by which the ossibility of surgical correction can be as-ertained. In the great majority of these ases the outlook is justifiably gloomy. The xtent of obliteration may vary from a lim-ted stenosis in a single duct to complete tresia or absence of all extrahepatic biliary tructures. However, the number of these nomalies which are amenable to surgical orrection is unfortunately small.

Historically, the interest of the medical profession was directed toward this relatively uncommon group of malformations by the study of 50 cases collected from the literature by Thompson in 1891. It remained, however, for Holmes in 1916 to call attention to the correctability of some of the reported cases. He estimated that the congenital biliary obstruction could have been relieved surgically in at least 16 per cent of the 114 recorded cases. In 1928 the first successful operation for biliary atresia was reported by Ladd (10). Nonetheless, Gray, DuShane, and Henegar were able to find only 13 operative successes in the literature up to 1949. They added a successful case of their own and 2 others as personal communications. Additional successes have subsequently been reported.

In 1951, Ahrens, Harris, and MacMahon estimated the number of reported cases of extrahepatic biliary tract atresia to be in excess of 250 cases. Most of the reports have been of isolated cases. Due to the rarity of this anomaly and the limited number of sizable series reported, it has seemed desirable to record the experience at this hospital with 31 proved cases of atresia of the extrahepatic bile ducts. All but 1 of the cases have been studied since 1935. Several additional cases, believed clinically to be instances of biliary atresia, have been excluded because other less common causes of obstructive neonatal jaundice, such as intrahepatic biliary atresia, inspissated bile or mucous plugs, and annular pancreas, could not be ruled out. For this reason, only those cases have been included in which the diagnosis was established at operation or on postmortem examination.

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INCIDENCE

The sex distribution of the patients in this series showed a slight female predominance. Eighteen of the patients were females and 13 were males. One was a negro infant and 30 were of the white race. No family history of biliary atresia was encountered and many of the families have had one or more normal children following the child with biliary atresia.

The rarity of biliary atresia makes its frequency somewhat difficult to assess. However, it is possible to obtain a rather rough estimate of its frequency by comparing the number of cases seen with some more frequently encountered anomaly whose incidence is more clearly established. Only 1 infant with biliary atresia has been born at this medical center in approximately 27,000 births. Yet, during this period, 6 infants were born with imperforate anus, an anomaly estimated to occur once in approximately

every 5,000 births. The ratio of the total number of proved cases of biliary atresia to those of imperforate anus seen at this hospital is 1:4 (31 cases to 120) while that of the series of Ladd and Gross (11) was 1:5 (45 cases to 214). Accordingly it would appear likely that biliary atresia might be expected to occur once in approximately every 20 to 30 thousand births.

EMBRYOGENESIS

The embryogenesis of extrahepatic biliary atresia is not clearly established. Although it has been suggested in the past that these anomalies were acquired, secondary to such conditions as congenital syphilis, fetal peritonitis, and erythroblastosis fetalis, these theories have generally been discarded. Ladd and Gross favored the concept that these malformations represented an arrest of maturation at the so-called "solid" stage of embryonic development. A similar solid state is seen in other segments of the alimentary tube. As Bremer points out, this solid stage is usually limited in its extent and rarely involves the entire alimentary tube at any one time. This solid stage results from a piling up of epithelial cells, supposedly in preparation for a phase of rapid growth and elongation. The wide range in the possible extent of both intrahepatic and extrahepatic biliary malformations, from local stenosis to complete fibrosis or absence, is difficult to explain merely as a developmental arrest. Perhaps these anomalies result more often from gross embryonic aberrations than from simple arrest at a certain stage of "normal" development.

CLINICAL FEATURES

Jaundice was a constant physical finding. It was present either at birth or shortly thereafter and became progressively more intense. Abdominal enlargement was often encountered and was generally associated with hepatomegaly. In addition, the biliary cirrhosis, caused by the extrahepatic biliary obstruction, produced clinical evidence of portal hypertension in the form of splenomegaly and esophageal varices. The occurrence of ascitic fluid also tended to influence the steady abdominal enlargement in the untreated, or untreatable, patient. It accompanied the progressive malnutrition of these patients and was presumably associated with excessive sodium retention, and a terminal reduction in serum protein levels. Due to the progressive increase in intra-abdominal pressure, umbilical and inguinal hernias tended to occur in some of the more advanced cases. For this reason, postoperative wound disruptions may be expected to be encountered more often in these patients.

Prematurity was seldom associated with biliary atresia and the birth weights of the infants were generally within normal limits. Although the early growth of these patients was relatively normal, the increment of weight gain decreased with the passage of time, and physical retardation and malnutrition were generally a part of the terminal picture.

The urine of these patients was dark and the stools remained light. Melena frequently occurred terminally and, when it did, it was commonly regarded as being due to a disturbance in the clotting mechanism secondary to hepatic insufficiency, to esophageal varices, or both. Evaluations of the bleeding and clotting mechanisms were only occasionally obtained. The values were usually normal during the early months and did not appear to change until the end approached. However, the bleeding time in 1 patient was found to be in excess of 35 minutes at 1 month of age. Despite his age, this patient also had marked hepatomegaly, petechiae and subcutaneous hemorrhages of the palms of his hands. Another patient was found to have a prothrombin time of 54 per cent of normal at 6 months of age.

Laboratory tests showed the stools to be acholic and the icteric index and serum bilirubin determinations to be markedly elevated. A mild anemia was often found. In 9 of the cases the red blood count was below 2 million and the hemoglobin below 8 grams per cent. In this regard, it should be stated that many of the patients were first seen relatively late in the course of their illness. Serum protein studies were carried out on 6 patients who had had unrelieved extrahepatic biliary obstruction since birth and the results

re presented in Table I. The obstruction ad existed in excess of 4 months since birth n all of the cases, and in 1 case a determinaion was made at both 6 and 12 months of ge. These figures show a rather remarkble maintenance of the total serum protein oncentration, and of its component albumin nd globulin levels, even in the presence of ongstanding total extrahepatic biliary obtruction. The change in the findings beween 6 and 12 months appears to be prinipally one of a reduction in the levels of oth albumin and globulin components. It hould be noted that, with the exception of patient who died at 26 months, all of the leaths in this series occurred before 13 nonths of age. The average age at death vas approximately 7 months.

The number of cases with associated nomalies was relatively small (16). Additional malformations were encountered in only 5 of the 31 cases (16 per cent). These nomalies involved the urinary tract in 4 of he 5 cases.

Included were: hypoplasia of kidney in 2 ases; absence of kidney in 1 case; atresia f ureter in 1 case; megaloureter in 1 case; mperforate anus in 1 case; stenosis of ileum n 1 case; situs inversus in 1 case; and tetralogy of Fallot in 1 case.

The principal conditions to be considered in the differential diagnosis are icterus neonatorum, erythroblastosis fetalis, and intraluminal bile duct obstruction from inspissated bile or mucous plugs. Icetus neonatorum is rather easily differentiated from biliary atresia by the simple process of waiting a few days. Icterus neonatorum soon disappears and is not associated with acholic stools. The diagnosis of erythroblastosis fetalis should be established during the first few hours of life so that replacement transfusion may be carried out if indicated. Parental and infant Rh blood typing and tests for anti-Rh agglutinins are valuable laboratory aids and should permit the diagnosis or exclusion of erythroblastosis fetalis within a relatively short period of time. Although cholagogue therapy will occasionally dislodge an obstructing bile or mucous plug, it is by no means universally successful and operation is often required to establish this diagnosis. Even operation is, at times, inconclusive due to the difficulty experienced by some in distinguishing between an atretic and fibrotic duct and a patent but collapsed and unused one. Less frequent causes of obstructive neonatal jaundice such as intrahepatic atresia and annular pancreas may be identified by exploratory laparotomy and liver biopsy.

TABLE I.—SERUM PROTEIN DETERMINATIONS ON PATIENTS WITH UNRELIEVED EXTRAHEPATIC BILIARY OBSTRUCTION SINCE BIRTH

Case No.	Age, months	Total protein, gm. per cent	Albumin, gm. per cent	Globulin, gm. per cent
1	4	8.7	5.6	3.1
2	4½	6.7	4.6	2.1
3	6	5.2	3.2	2.0
4	10	5.6	3.8	1.8
5	11	7.8	5.1	2.7
6	6	7.5	5.5	2.0
	12	2.7	1.7	1.0

SURGICAL MANAGEMENT

It should be emphasized that long delays in carrying out exploratory operation are both unnecessary and dangerous. The principal differential considerations can be rather readily ruled in or out. Thereafter, repeated laboratory tests may prove to be considerably more time-consuming than diagnostic. Although operation is not, strictly speaking, an emergency affair, it is far better that it be undertaken early than late, at the termination of much observation. If the jaundice persists, and the stools remain acholic for a few days, even on a trial of cholagogue therapy, and erythroblastosis has been ruled out, operation should be undertaken without delay in order to give the patient a reasonable chance for survival should he be so fortunate as to have a surgically correctable anomaly. The operation is a relatively simple one and the mortality should be low.

The results in the correctable cases in this series would seem to illustrate the hazards of prolonged watchful waiting prior to hospital admission. The ages of the 31 patients,

TABLE II.—INCIDENCE OF CORRECTABILITY IN PROVED CASES OF EXTRAHEPATIC BILIARY ATRESIA

Author	Date	Institution	No. of cases	No. correctable	Incidence of correctability per cent
Donovan	1937	Babies Hospital, New York	11	1	9
Ladd and Gross	1941	Children's Hospital Boston	45	9	20
Amberg and Zuschlag	1944	Mayo Clinic	30	4	13
Gray, DuShane and Henegar	1948				
Leyva and Madigan	1948	Children's Hospital Washington, D.C.	18	9	50
Moore	1952	Indiana University Medical Center	31	8	26
Total			135	31	23

at the time of their admission to this hospital, ranged from birth to 11 months and averaged 4½ months. Several other patients were between 7 and 13 months of age when first seen and were obviously in a terminal condition. They have not been included in the series since the diagnosis was not clearly established by operation or necropsy.

The nature and extent of the obliterative extrahepatic malformation was determined by operation alone in 16 cases, by necropsy in 4, and by both operation and necropsy in 11. Eight of the 31 patients (26 per cent) had surgically correctable anomalies. In 6 of these cases the hepatic duct was dilated while the gallbladder and common duct were atretic. In 1 case the gallbladder and hepatic duct were dilated and the common duct was atretic; and in 1 case two segmental atresias were present. Due to a natural tendency to record successful rather than unsuccessful cases, a clear picture of the incidence of correctability is difficult to obtain from the literature by a study of isolated case reports. Accordingly, 5 of the larger series, in which the correctability of proved cases was given, have been selected for analysis (Table II). It is found that 31 of 135 cases (23 per cent) were correctable. Although Gerrish and Cole stated that only 1 of their 25 cases was correctable they did not give the nature of the anomalies or state the number of cases in which the diagnosis was proved by operation or necropsy. The incidence of correctability in the 19 cases reported by Stolkind is difficult to judge accurately from the necropsy descriptions presented.

In the majority of the 23 noncorrectable cases, the extrahepatic duct system was unidentifiable or remained simply as thin, fibrous cords (14 cases). The atresia or obliteration in these cases was total. In 8 cases, the gallbladder was present and patent while the rest of the ductal system was absent. In 2 of these cases the gallbladder was markedly distended by a colorless, mucoid fluid. Although the gallbladder and the common duct were patent and communicated in a normal manner with the duodenum in 1 case, the hepatic duct was totally atretic.

The experience with the 8 correctable cases is summarized in Table III. The average age of these patients was 5 months. Five of them were 5½ months of age or older, an age well within the twilight zone of the reversibility of impaired hepatic function secondary to biliary cirrhosis. Indeed, Ladd and Gross found 5 months to be the average age of death of noncorrectable cases in their series.

One of these cases is of particular interest because no extrahepatic biliary structures were encountered on exploration at 6 months of age. The atresia, therefore, was regarded as noncorrectable. A careful dissection of the hepatic artery and adjacent structures had been carried out. The patient died during a second admission to this hospital at 12 months of age. On postmortem examination, a markedly dilated, blind ending hepatic duct was found on entering the lesser peritoneal cavity. It was located in an unusual position, posterior to the gastrohepatic ligament, and could not be seen without exposing the lesser cavity through this structure. The hepatic duct communicated proximally with the quadrate and left lobes of the liver by 2 smaller ducts.

Cases 2, 5, and 6 were rather hopeless preoperatively with respect to both their age and general condition and, for these reasons, their postoperative demise can hard-

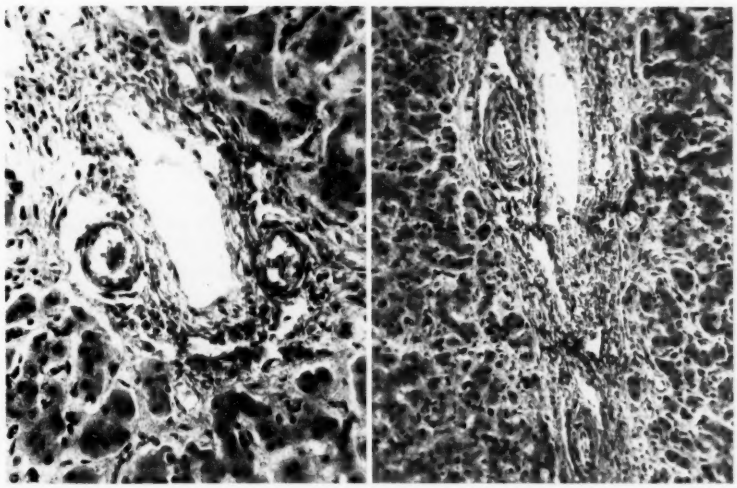


Fig. 1. Photomicrographs of 2 representative portal areas in Case 6 (Table IV) showing intrahepatic biliary atresia. The absence of portal fibrosis and round cell infiltration is conspicuous.

y be regarded as totally unexpected. Case was operated upon at 5½ months of age. The congenital obstruction was satisfactorily relieved by a hepaticoduodenostomy. The stools became colored with bile and the jaundice disappeared. The patient was never jaundiced again. Nevertheless, she died at home 4 months later with ascites, metabolic disturbances, and bronchopneumonia. Although the operation was a technical success it came too late to benefit the patient. Of the 3 younger patients, 2 died and 1 recovered. One of those who died was admitted to the hospital in a wretched condition with opisthotonus and suspected intracranial pathology. The other was cyanotic as well as jaundiced and was found at postmortem to have the tetralogy of Fallot, stenosis of the ileum and right renal hypoplasia.

ASSOCIATED INTRAHEPATIC FINDINGS

Sections of liver were available for microscopic study in 19 cases. The sections were obtained at operation in 5 cases and at autopsy in 14. It was felt desirable to evaluate the incidence of coexisting intrahepatic biliary atresia in cases of extrahepatic atresia and to correlate the duration of extrahepatic obstruction with the degree of portal fibrosis and bile duct proliferation (Table IV). Intrahepatic biliary atresia was encountered in only 1 case. This patient had died 7 days following an exploratory operation and was found, in addition, to have bilateral renal hypoplasia with atresia of the upper third of the right ureter. No bile ducts or cholangiolar epithelium were encountered in any of the 14 portal areas studied (Fig. 1). In another case intrahepatic bile ducts were present but markedly reduced in number. In all other cases, the bile ducts in the portal areas were either normal or considerably increased in number. Although most of the ducts were relatively small, the sections generally being taken from peripheral areas, larger bile ducts were occasionally encountered (Fig. 2). It would thus appear that the incidence of intrahepatic atresia in cases of extrahepatic atresia is rather low. Intrahepatic atresia, on the other hand, is often associated with obliteration of the extrahepatic ducts. Ahrens and his associates have recently reviewed 13 reported cases of intrahepatic atresia, including 2 of their own. Extrahepatic atresia existed in 9 of the 13. The extrahepatic bile ducts were patent in only 4 of their cases and were normal in but 3 of them.

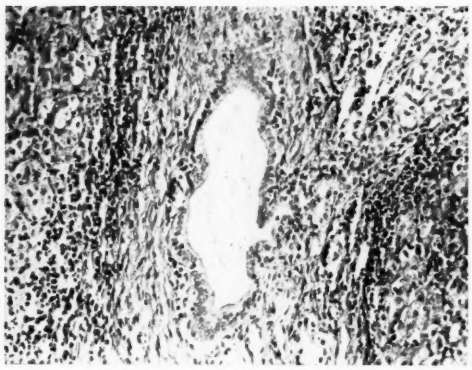


Fig. 2. Photomicrograph of larger collecting bile duct in Case 3 (Table IV). Round cell infiltration and early fibrosis are observed in this case even at 1 month of age.

It is of interest to note the correlation between the duration of obstruction and the extent of portal reaction. The onset of portal fibrosis was early and it appeared to be well under way by 6 weeks of age. Considerable periportal round cell infiltration occurred early while the late appearance was more often one of dense scarring in the portal and periportal areas with only small islands of hepatic cells remaining clustered about the central veins (Fig. 3). Focal necrosis of the hepatic cells occurred in only 1 case. The hepatic cells otherwise appeared normal, the changes in hepatic architecture resulting primarily from advancing biliary cirrhosis. A rather extensive proliferation of the portal biliary epithelium consistently accompanied the portal fibrosis (Fig. 4).

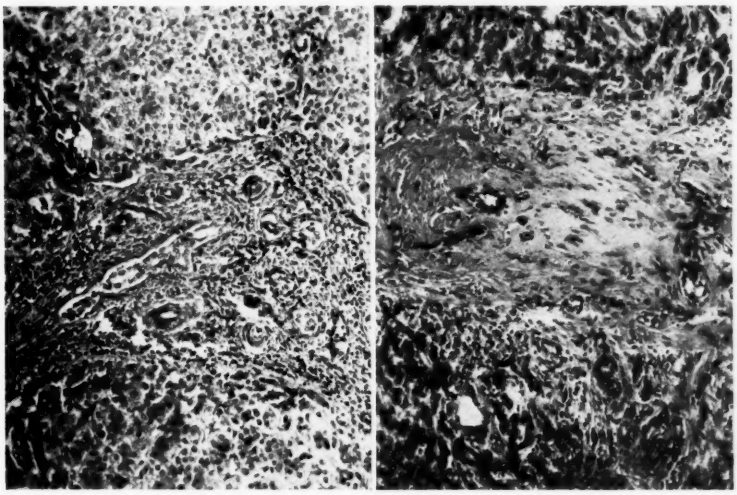
The 2 exceptions to the pattern of increasing fibrosis and ductal proliferation with advancing age were the case with intrahepatic atresia and the one with a marked reduction in intrahepatic bile ducts. They both showed a rather remarkable freedom from the ravages of biliary cirrhosis. The article by Ahrens and his associates contains photomicrographs of portal areas from a case of intrahepatic atresia. Their patient had died at 3½ years of age and the portal areas showed a similar freedom from fibrosis. This absence of extensive portal scarring and biliary proliferation may well account for the greater "longevity" of patients with intrahepatic biliary atresia.

The early appearance of portal hypertension was suggested in 1 case in which sections through the esophagus, following death at 2 months of age, showed evidence

TABLE III.—SUMMARY OF EXPERIENCE WITH 8 CORRECTABLE CASES

Case No. Year	Age, months	Operative findings	Operation	Result	Remarks
1 1938	11 days	Dilated hepatic duct	Hepaticogastrostomy	Died	Opisthotonus and poor condition on admission. Death 3 days postoperatively. No autopsy
2 1940	10½	Dilated hepatic duct	Hepaticoduodenostomy	Died	Malnutrition, abdominal enlargement, ascites, and clubbing of fingers and toes. Death 1 day postoperatively. Autopsy showed only malnutrition and biliary atresia
3 1942	5½	Dilated hepatic duct	Hepaticoduodenostomy	Recovered (temporarily)	Jaundice disappeared and stools contained bile. Ascites and bronchopneumonia 2 months following discharge. Died at home 4 months postoperatively. Remained free of jaundice
4 1945	6	No ductal structures found	Exploration only	Died	Death at 12 months. At autopsy markedly dilated hepatic duct found in lesser peritoneal cavity behind gastrohepatic ligament
5 1947	9	Dilated hepatic duct	Hepaticojejunostomy	Died	Admission temperature 102°. Malnutrition. Death 3 days postoperatively. Bronchopneumonia found at autopsy
6 1948	6	Dilated hepatic duct	Hepaticojejunostomy	Died	Pneumonia and fever of 103° on admission. Marked abdominal enlargement and ascites. Death 12 days postoperatively. Bronchopneumonia found at autopsy
7 1949	1	Dilated gallbladder and hepatic duct	Cholecystojejunostomy	Died	Also cyanotic on admission with systolic murmur. Death 12 days postoperatively. Tetralogy of Fallot, right renal hypoplasia and ileal stenosis found at autopsy
8* 1951	1½	Two segmental atresias	Transcholedochal and transduodenal operation	Recovered	Free of jaundice and doing well at 13 months of age

*Operative findings and procedure described in greater detail elsewhere (23).



a b

Fig. 3. Photomicrographs illustrating: a, the early round cell infiltration and loose connective tissue found in Case 4 (Table IV) at 1½ months of age as compared with, b, the more dense scarring encountered in Case 19 (Table IV) at 12 months.

of esophageal varices (Fig. 5). Portal fibrosis and ductal proliferation were both marked in this case despite the relatively early age of the patient (Case 5 in Table IV). It should be added that bronchopneumonia was frequently found on study of lung sections in autopsy cases.

DISCUSSION

Eight of the 31 patients in this series had atresias of the extrahepatic biliary tract which were surgically correctable. Nonetheless, only 1 patient is living with an excellent chance for continued survival and good health as the result of surgical relief of biliary obstruction. These results illustrate all too well the tragedy of delay. All of the patients had been jaundiced since birth, yet many of them did not arrive at the hospital until their condition had become terminal and their prognosis hopeless, regardless of their "correctability."

The average age at the time of admission to the hospital, for the total series, was 4½ months. Of the 8 correctable cases, 5 were in excess of 5½ months of age when first seen. Furthermore, 2 of the remaining 3 cases were severely handicapped; 1 by multiple anomalies and 1 by opisthotonus and suspected intracranial pathology.

It would appear that the successful management of correctable cases of biliary atresia involves early operation. The operation is a relatively simple one and the mortality should be low. A review of the reported successes in cases of correctable biliary atresia reveals that the majority of them were operated upon early. The age of the patient was given in 9 of the cases. In 4 of them the patient was 1 month of age or younger and in 4 the ages ranged from 1 to 2 months. One patient was 3 months of age. Lanman has recently emphasized the importance of operating upon these patients during the first 4 or 5 weeks of life. Perhaps they should be operated upon even sooner. Neonatal jaundice should, in effect, be regarded as an emergency. The work-up should be prompt and thorough and operation should be carried out without delay when there is a reasonable suspicion of biliary atresia.

Although Gerrish and Cole, in 1951, advocated prolonged cholagogue therapy in negro infants, the published experience with biliary

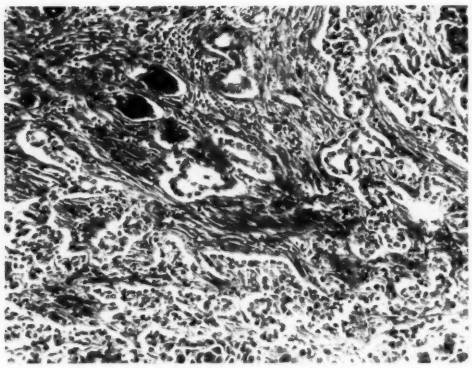


Fig. 4. Photomicrograph demonstrating bile duct proliferation and portal fibrosis in Case 15 (Table IV) at 8 months.

atresia does not appear to suggest that the race of the patient should alter the plan of management. One of the proved instances of extrahepatic atresia recorded herein occurred in a negro infant and was of the correctable type. Other proved cases in negro infants have been reported by Donovan, Pasachoff, and Finlayson. Biliary atresia has also been observed in oriental infants. Accordingly, it would seem unwise to rule out the possibility of congenital extrahepatic biliary atresia as the cause of obstructive neonatal jaundice in any case simply on the basis of the race of the patient.

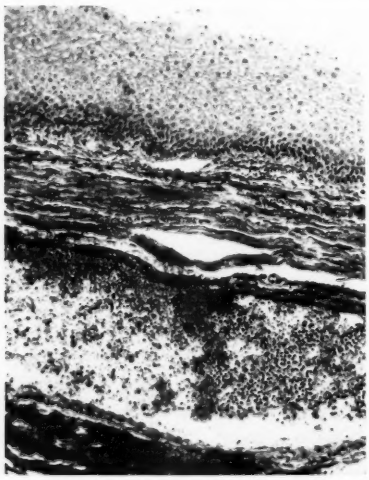


Fig. 5. Photomicrograph of an esophageal varix found at necropsy in Case 5 (Table IV) at 2 months of age.

The correctability of the atresia can only be determined by operative inspection of the extrahepatic biliary tract. The definitive approach in correctable cases is directed toward the establishment of hepatic and proximal extrahepatic biliary decompression by an anastomosis of the extrahepatic duct remnant with an adjacent segment of the proximal gastrointestinal tract, preferably the duodenum. The type of enteric anastomosis, whether hepatic duct, gallbladder, or common duct is used, depends, of course, on the nature of the biliary tract anomaly encountered. It should be noted that no extrahepatic ducts were identified at operation in 1 patient who was found, at necropsy 6 months later, to have a markedly dilated hepatic duct in the lesser peritoneal cavity. This duct remnant was in continuity with the intrahepatic ductal system. A similar unhappy experience has been reported by Leyva and Madigan. These tragic occurrences should emphasize the importance of carrying out a careful search for patent duct remnants at operation, including opening and visualizing the lesser peritoneal cavity.

Active supportive measures should be undertaken in both the preoperative and postoperative periods. Fluid and electrolyte administration should be carefully regulated and adequte oral or parenteral nutrition maintained. Gastric suction and whole blood administration should be utilized when indicated. Antibiotics and vitamin K are valuable adjuvants.

Several interesting observations may be made from the histologic study of sections of liver in 19 of the cases and from a correlation of this material with clinical findings and the prognosis for longevity. Portal fibrosis and the associated round cell infiltration and bile duct proliferation appeared to be well established by 2 months of age. The accompanying portal hypertension with splenomegaly and esophageal varices occurred relatively early. Except for a decrease in their number as the result of progressive biliary cirrhosis, the hepatic cells appeared normal, and the serum protein levels re-

TABLE IV.—STATUS OF INTRAHEPATIC BILIARY SYSTEM IN 19 CASES OF EXTRAHEPATIC ATRESIA

Case No. Sex	Age, months	Occasion of liver biopsy	Nature of extrahepatic atresia	Intrahepatic bile ducts	Portal fibrosis	Portal bile duct proliferation
1 Female	1 day	Autopsy	Noncorrectable	Present	o	o
2 Female	1	Autopsy	Correctable	Present	+	o
3 Male	1	Operation	Noncorrectable	Present	+	o
4 Female	1½	Autopsy	Noncorrectable	Present	++	+
5 Female	2	Autopsy	Noncorrectable	Present	+++	+++
6 Male	3	Autopsy	Noncorrectable	Absent	o	o
7 Male	4	Autopsy	Correctable	Present	+++	+++
8 Male	4	Autopsy	Noncorrectable	Present	+++	+++
9 Male	4½	Operation	Noncorrectable	Present	++++	++++
10 Male	5	Autopsy	Noncorrectable	Present*	+	o
11 Female	6½	Autopsy	Noncorrectable	Present	+++	+++
12 Male	7	Operation	Noncorrectable	Present	++++	+++
13 Male	8	Operation	Noncorrectable	Present	++++	++++
14 Male	8	Autopsy	Noncorrectable	Present	++++	+++
15 Female	8	Autopsy	Noncorrectable	Present	++++	++++
16 Female	9	Autopsy	Correctable	Present	++++	++++
17 Female	11	Operation	Noncorrectable	Present	++++	++++
18 Female	11	Autopsy	Correctable	Present	++++	++++
19 Male	12	Autopsy	Correctable	Present	++++	+++

*Although an occasional bile duct was identified, they were markedly reduced in number.

mained essentially within normal limits until the end was near. The irreversibility of hepatic damage seemed to occur relatively early. Although biliary obstruction and jaundice were relieved operatively in 1 case at 5½ months of age, the patient died at home 4 months later with ascites and presumed hepatic insufficiency. In addition, accompanying intrahepatic biliary atresia was rare. It was encountered in only 1 of the 19 cases studied. There was a conspicuous freedom from portal fibrosis, round cell and duct proliferation in this case. Similar findings have been reported in cases of intrahepatic atresia by Ahrens and his associates. In 4 of the cases reviewed by them, death did not occur until 3 to 3½ years of age and 1 other patient was still living at 5 years. They found skin xanthomatosis to be an interesting feature in the majority of those cases of intrahepatic atresia surviving over 3 years. Since virtually all patients with unrelieved extrahepatic atresia and patent intrahepatic bile ducts die before 12 months of age, the significantly greater longevity of those patients with intrahepatic atresia is, perhaps, best explained by their freedom from the ravages of biliary cirrhosis.

The outlook for the majority of cases of extrahepatic atresia, those with noncorrectable atresias, remains bleak. This situation might be improved if some effective method could be devised for draining off the accumulating bile into the intestinal tract before the onset of portal fibrosis. Although it has never been carried out successfully, the concept of cholangioenterostomy for biliary atresia is by no means new. It appears, however, that the large intrahepatic ducts at the hilum of the liver are also atretic when a noncorrectable atresia exists. For this reason, section through the liver in this area will not produce a patent bile duct large enough to be of use for the Longmire operation.

The study reported herein indicates that the intrahepatic ducts are generally patent when an extrahepatic atresia exists, although those at the hilum of the liver may not be large enough for a single enteric anastomosis. Furthermore, there is no apparent alteration in the structure of the bile canaliculi in these cases. In this regard, it is of interest that Grafflin and Bagley have shown recently by fluorescence microscopy in animals, that the bile canaliculi of the liver are normally united in one continuous network. It is, theoretically, possible that drainage of several of the canaliculi and cholangioles, distended by extrahepatic obstruction, might relieve the pressure in the rest of the intrahepatic ductal system in the manner of a safety valve. This decompression might be achieved by the anastomosis of a Roux-Y limb of jejunum to a cut surface of the liver. Blood loss from the cut liver would be a problem. Active intravenous replacement of lost blood, administration of antibiotics in large doses, and the vigorous use of such cholagogues as magnesium sulfate, decholin and ketochol would all be essential in the postoperative management. It is desirable that animal experiments be carried out to evaluate the effectiveness of biliary tract decompression by Roux-Y "hepatojejunostomy."

SUMMARY

1. The literature concerning congenital atresia of the extrahepatic bile ducts is reviewed.

2. Thirty-one proved cases of extrahepatic biliary atresia are reported and the clinical findings discussed. The atresia was of a surgically correctable type in but 8 of the cases (26 per cent) and only 1 of them is living and free of symptoms.

3. It is estimated that extrahepatic biliary atresia occurs approximately once in every 20 to 30 thousand births. There appears to be no clear sex, race, or familial predominance and the incidence of associated anomalies is relatively low (16 per cent).

4. The average age of the 31 patients at the time of their admission to the hospital was 4½ months and 5 of the 8 patients with correctable atresias were in excess of 5½ months of age. The average life span in the noncorrectable cases was found to be 7 months. These findings illustrate the inadvisability of prolonged watchful waiting for the disappearance of neonatal jaundice.

5. The results of the surgical management of the 8 correctable cases are summarized and the importance of prompt evaluation and early operation is emphasized.

6. Exploration of the extrahepatic duct area should also include investigation of the lesser peritoneal cavity to avoid overlooking patent duct remnants in continuity with the liver, as occurred in 1 of the cases.

7. Sections of liver were available for microscopic study in 19 cases. Intrahepatic biliary atresia was encountered in only 1 of them. Portal fibrosis, with round cell infiltration and bile duct proliferation, was found to be well established by 2 months of age. Evidence of portal hypertension in the form of esophageal varices and splenomegaly also appeared early. Only the case of intrahepatic atresia and the 1 case with a markedly reduced number of intrahepatic bile ducts were spared the progressive ravages of this portal reaction. This finding suggests that the freedom of cases of intrahepatic atresia from biliary cirrhosis accounts for the significantly greater longevity observed in these cases.

8. It is urged that renewed efforts be made to bring within the realm of effective surgical management that unfortunate majority of patients whose extrahepatic biliary

atresia is of the type considered noncorrectable by contemporary standards. The use of a Roux-Y hepatojejunostomy, supplemented by cholagogues and antibiotics, is perhaps worthy of further consideration and investigation.

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INGUINAL AND FEMORAL HERNIAS

A Follow-up Study

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IN spite of continued interest in the anatomy of the inguinal and femoral regions and the further elaboration of techniques for operative management of hernias in these areas, the recurrence rate following herniorrhaphy has remained significantly high. The recurrence rate for indirect inguinal hernia is reported from 3 to 20 per cent, and that of direct inguinal hernia from 5 to 35 per cent. Recurrences following femoral hernia repair have been reported from 3 to 30 per cent. The variation in recurrence rates reported is understandable since age, sex, type of hernia, tissue quality, defect size, occupation, associated conditions producing increased intra-abdominal pressure, suture material, type of repair, surgeon, and many other factors are involved in determining whether or not a hernia will recur following repair. Also the follow-up interval and percentage of personal follow-up examinations are certainly factors of considerable importance in evaluating the validity of reported results of herniorrhaphy. It has been generally stated that nearly all recurrences will occur within 12 to 24 months. The data to be presented are not in accord with this assumption.

The experience at the Hospital of the University of Pennsylvania with inguinal and femoral herniorrhaphy between January 1, 1945 and January 1, 1949 has been reviewed. During this time 1,082 herniorrhaphies were performed upon 957 patients in 1,022 operative sessions. The mortality rate, by which is implied death within 30 days following operation, was 0.29 per cent. There were 2 deaths due to pulmonary embolus and 1 due to suicide. There was no death due to cardiovascular or renal complication, although 58 per cent of the patients were over 40 and 13 per cent were over 60 years old.

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INCIDENCE OF FEMORAL, DIRECT, INDIRECT, AND RECURRENT INGUINAL HERNIAS WITH REGARD TO AGE, SEX, AND SIDE INVOLVED

Table I and Graph 1 show the relative incidence of types of hernia. The most common hernia was the indirect inguinal representing about 66 per cent of the total. Direct hernias occurred in approximately 20 per cent. Thirty-one out of 219 direct hernias also had an indirect sac, the so-called pantaloon hernia. Femoral hernias and recurrent inguinal hernias each represented approximately 7 per cent. There were no recurrent femoral hernias encountered in this series.

Eighty-six per cent of the total hernias occurred in males. Approximately 84 per cent of the femoral hernias occurred in females. Nevertheless, the most frequent hernia encountered in woman was the indirect inguinal occurring in 51 per cent. Ninety-five per cent of the direct hernias occurred in males; however, 10 direct hernias were seen in women. Seventy-five recurrent inguinal hernias were encountered; all but 1 of these occurred in men. The 1 case occurring in a woman was a direct hernia which occurred 2 years following the repair of a femoral hernia on the same side. Since the femoral repair was by the inguinal approach this was considered a recurrent hernia.

Table I also shows the distribution according to side involved. Direct hernias occurred in essentially equal numbers on both sides. Femoral hernias were twice as common on the right side. Indirect and recurrent inguinal hernias were somewhat more common on the right.

The relationship of age to the type of hernia is shown in Table II. Ninety-eight per cent of

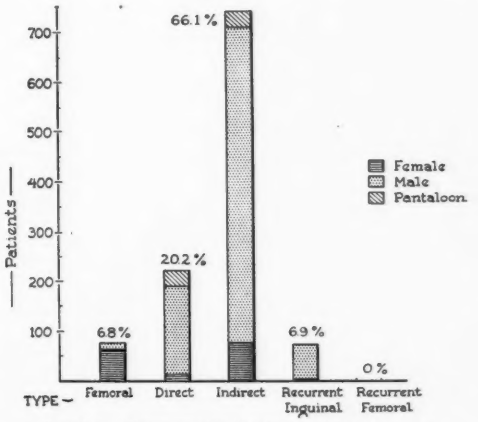
the hernias encountered in patients under 20 years of age were indirect inguinal hernias. Two femoral hernias were seen in patients under 20 years old. However, 89 per cent of the femoral hernias occurred in patients over 40. No direct hernias were seen in patients under 20; the greatest number occurred in patients 50 to 60 years of age. Indirect inguinal hernias were common in all decades. Most of the recurrent inguinal hernias were seen in patients 40 to 60 years of age.

METHODS OF TREATMENT

Table III indicates the type of repair employed with regard to the type of hernia encountered. The Halsted type of repair was employed in over half the cases. It was used in 78 per cent of the direct hernias and was also the most frequently used repair for indirect inguinal and recurrent inguinal hernias. The Bassini repair was used in approximately 25 per cent of the cases, mostly for indirect inguinal hernias. Ferguson repairs were used almost exclusively for indirect inguinal hernias and most of these were in children. Only 8 McVay repairs were performed during this period. This method is being used more frequently now. Ligation of the sac alone was performed 23 times. These were in young children, with the exception of 2 unusual circumstances. Sixty-two of the 74 femoral hernias treated were repaired by the femoral approach.

Table IV shows the influence of age on the type of repair elected. In patients over 40 years of age, the Halsted repair was most frequently used. We were somewhat surprised to find it employed in 49 patients under 20 years of age. Bassini repairs were used in all decades with similar frequency. Most of the Ferguson repairs and ligations of the hernial sac alone were done in young children for indirect inguinal hernias. We question the necessity of employing the Halsted type of repair in patients under the age of 20, or the Bassini type of repair in patients under the age of 10 as was done in these few cases. In general we have employed a modified Ferguson technique almost exclusively for children under 10, and a Bassini type repair for young adults in recent years.

Table V shows that a variety of suture materials was employed during this period. Silk was the most popular being employed in ap-



Graph 1. Comparative incidence of hernia types.

TABLE I.—INCIDENCE OF TYPES OF HERNIA WITH REGARD TO SEX AND SIDE INVOLVED

	Total		Female		Male		Right		Left	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Femoral	74	6.8	62	83.8	12	16.2	49	66.3	25	33.7
Direct incl. pantaloon	219 (31)	20.2	10	4.6	209	95.4	111	50.9	108	49.1
Indirect	714	66.1	79	11.2	635	88.8	420	58.9	294	41.1
Recurrent inguinal	75	6.9	1	1.3	74	98.7	45	60	30	40
Recurrent femoral	0		0		0		0		0	
Total	1082		152	14	930	86	625	57.6	457	42.4

TABLE II.—INCIDENCE OF TYPES OF HERNIA WITH REGARD TO AGE OF PATIENT

	Total		Age groups, years						
	No.	Per cent	0–10	10–20	20–30	30–40	40–50	50–60	over 60
Femoral	74	6.8	2	0	1	7	13	28	23
Direct incl. pantaloon	219 (31)	20.2	0	0	10	44	57	77	31
Indirect	714	66.1	121	98	81	111	116	107	80
Recurrent inguinal	75	6.9	1	2	3	9	25	29	6
Recurrent femoral	0		0	0	0	0	0	0	0
Total	1082		124	100	95	171	211	241	140

TABLE III.—TYPE OF HERNIORRHAPHY EMPLOYED WITH REGARD TO TYPE OF HERNIA

	No.	Per cent	Femoral	Direct incl. pantaloon	Indirect	Recurrent inguinal
Halsted	581	58.8	2	173	347	59
Bassini	284	26.2	2	38	233	11
Ferguson	105	9.7	0	2	102	1
McVay	27	2.5	8	5	10	4
Ligation sac only	23	2.1	0	1	22	0
Femoral below	62	5.7	62	—	—	—
Total	1082		74	219	714	75

proximately ⅓ of the cases. Wire and catgut were used nearly as often. Cotton and fascial strips were used in a few more than 50 cases each. Only 1 cutis graft was used during this period and no tantalum mesh.

Wire, silk, and cotton were used in all age groups. Catgut was most frequently used in children, although it too was employed in significant amounts in the older age groups. Fascial grafts were employed primarily in patients 40 to 60 years of age with large or recurrent hernias. No fascial graft was used in those patients who were under the age of 20 years.

Silk was most frequently used for indirect inguinal hernias with wire and catgut nearly as popular. Silk and wire were most frequently used for the direct hernias. Catgut was most frequently used for the femoral repairs by the femoral approach. Wire or fascia was most frequently chosen for repair of a recurrent inguinal hernia.

TABLE IV.—TYPE OF HERNIORRHAPHY EMPLOYED WITH REGARD TO AGE OF PATIENT

	No.	Per cent	Age group, years						
			0–10	10–20	20–30	30–40	40–50	50–60	over 60
Halsted	581	53.8	4	45	57	107	132	155	81
Bassini	284	26.2	31	35	36	51	60	46	25
Ferguson	105	9.7	69	16	1	4	4	6	5
McVay	27	25	1	4	0	3	5	9	5
Ligation sac only	23	2.1	18	0	0	0	0	2	3
Femoral below	62	5.7	1	0	1	6	10	23	21
Total	1082		124	100	95	171	211	241	140

TABLE V.—SUTURE MATERIAL EMPLOYED WITH REGARD TO AGE OF PATIENT AND TYPE OF HERNIA

	Total		Age group, years				Femoral	Direct incl. pantaloon	Indirect	Recurrent inguinal
	No.	Per cent	0–20	20–40	40–60	over 60				
Wire	313	29.0	21	87	160	45	13	65	206	29
Silk	367	33.8	84	110	130	43	23	70	261	13
Cotton	55	5.1	9	10	28	8	0	18	32	5
Catgut	291	26.9	110	50	95	36	38	46	196	11
Fascia	56	5.2	0	9	39	8	0	20	19	17
Total	1082		224	266	452	140	74	219	714	75

ANESTHESIA

Spinal anesthesia was used in over 75 per cent of the cases. Spinal anesthesia was used in 95 out of 140 patients over 60 years old. General anesthesia was used for 98 per cent of the children under 10 years of age. Local anesthesia was used in 55 patients or 5 per cent of the total; 39 of these were over 60 years old.

BILATERAL HERNIAS

One hundred and twenty-five of these patients were found to have bilateral hernias in varying combination. These 250 hernias were repaired during 190 operations. There were 120 simultaneous repairs and 130 staged repairs. Of these, in 48 the interval was less than 10 days, in 2 from 10 to 20 days, in 6 from 3 to 6 weeks, and in 74 more than 6 weeks.

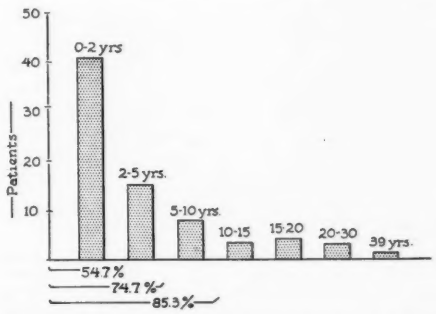
RESULTS OF TREATMENT

Follow-up examinations 2 to 5 years after operation were obtained for 766 herniorrhaphies or 71 per cent. The following results to be reported are based on a 2 year follow-up examination. We wish to place some limitation on conclusions drawn from examinations at this interval. It has been stated that 68 per cent of recurrences appear by 6 months (4); also that 93 per cent of recurrences will appear by the end of 2 years (6). In an attempt to gain some impression as to the length of follow-up period required to exclude the probability of recurrence, we examined the histories of the 75 recurrent hernias encountered during this period to determine how long following operation the recurrence appeared. Graph 2 shows that only 55 per cent had ap-

peared by the end of 2 years. Seventy-five per cent had appeared by the end of 5 years, 85 per cent by the end of 10 years, and recurrences continued to appear as late as 40 years following operation.

The recurrence rates at the 2 year interval were determined for the various types of hernia. Five per cent of the direct hernias recurred within 2 years. Slightly over 4 per cent of the indirect hernias recurred during the same period. From this, 72 per cent of the inguinal recurrences were indirect. The percentage of indirect recurrences has varied in different series from 12.3 per cent to 95.2 per cent. No recurrence occurred through the femoral area after either femoral or inguinal repairs. In 1 case a direct hernia appeared following a femoral repair. This was considered as a recurrence, giving a femoral recurrence rate of 2.9 per cent. The highest recurrence rate was in previously recurrent hernias at the subsequent repair. According to this series, if an inguinal hernia has recurred once it has a 21 per cent chance of recurring again within 2 years of the second repair.

These operations were performed by a large number of surgeons, both senior staff men and residents. Table VII is a comparison of the recurrence rates for a group of resident surgeons, for 2 individual senior staff surgeons, and for a group of senior staff surgeons. The similarity in recurrence rates for the indirect inguinal hernias is apparent. There was only 1 recurrence following femoral repair, which has been previously mentioned. The factor of greatest influence in the overall recurrence rate appeared to be the number of recurrent inguinal hernias treated. The highest recurrence rate for all 4 groups was in this category. Surgeon B with the highest overall recurrence rate took care of half of the recurrent hernias treated, while surgeon C with the lowest rate took care of only 3 recurrent hernias, none of which again recurred within 2 years. During this period he also cared for 26 direct hernias, none of which recurred within 2 years. However, 2 of these recurred prior to 5 years, giving him a 5 year recurrence rate comparable to the others. Residents under supervision were able to achieve results comparable to those obtained by senior surgeons.



Graph 2. Interval between herniorrhaphy and recurrence.

The relationship of recurrence to age was of interest. There were no recurrences encountered in children under the age of 10 years. The recurrence rates for the second, third, and fourth decades were 2.3 per cent, 4 per cent, and 5 per cent respectively. The highest recurrence rates were in the fifth and sixth decades and were 11.1 per cent and 12.2 per cent respectively. In patients over 60 years of age the recurrence rate again became less and was 3.7 per cent.

The predominance of recurrences in the male was striking. There were 42 recurrences detected upon examination. Only one of these was in a female and, as previously described, this was a direct recurrence following a previous femoral repair by the inguinal approach. This gave an overall recurrence rate for females of 1.1 per cent and for males of 6.1 per cent. During this period there were 6 herniorrhaphies in males accompanied by orchiectomy. This is too small a group to be significant but it is of interest that none of these recurred. The low recurrence rate in women and in men after orchiectomy supports the

TABLE VI.—ANESTHESIA EMPLOYED WITH REGARD TO AGE OF PATIENT

	Total		Age group, years				
	No.	Per cent	0–10	10–20	20–50	50–60	over 60
Local	55	5.2	2	0	5	9	39
Spinal	841	77.6	1	73	457	215	95
General	186	17.2	121	27	15	17	6
Total	1082		124	100	477	241	140

TABLE VII.—RECURRENCE RATES WITH REGARD TO SURGEON AND TYPE OF HERNIA

	Overall Per cent	Direct incl. pantaloon Per cent	Indirect Per cent	Femoral Per cent	Recurrent inguinal Per cent
Surgeon(s) A.	5.7	5.0	4.7	11 (1/11)	10
Surgeon B.	7.1	5.4	4.8	0	29 (7/24)
Surgeon C.	3.2	0 (0/26)	4.9	0	0 (0/3)
Surgeon(s) D.	6.4	10	3.4	0	33.3 (3/9)

argument that adequate closure of the internal ring is of particular importance, and suggests that in difficult or recurrent hernias in older patients orchiectomy may be justified.

The influence of the type suture materials employed upon the recurrence rate was examined. The overall recurrence rate for procedures employing wire was 5.5 per cent, for silk 3.3 per cent, for catgut 2.9 per cent, for cotton 11.7 per cent, and for fascia 20 per cent. Wire and silk were apparently satisfactory suture materials under a variety of conditions. The number of cases repaired with cotton was small, being only 55, so that the high rate observed with its use is open to question. Catgut had the lowest recurrence rate but it should be remembered that ⅓ of it was used in children under 10, who have no appreciable recurrence rate anyway and additional amounts were used in repair of femoral hernias by the femoral approach, a procedure also carrying a negligible recurrence rate during this period. Fascial strips were used mostly for recurrent and difficult repairs. The recurrence in 20 per cent of cases in which this was employed indicates that, in this series at least, the use of fascia did not solve this problem.

The relationship of the recurrence rate to the type of repair employed was examined. The overall recurrence rate in Halsted type repairs was 6.7 per cent, for Bassini repairs 2.9 per cent, for Ferguson repairs 4.5 per cent, for McVay repairs 6.6 per cent, and for femoral repairs 3.6 per cent. The higher incidence of recurrence following Halsted repairs has been emphasized by previous authors. This is not justified unless interpreted in the light of variables previously described. The Halsted repairs were commonly used for recurrent and difficult hernias in older patients, in whom the recurrence rate is high by any type repair. The Bassini repairs were used in younger adults, in whom the recurrence rate is low. None of the children under 10 repaired by the Ferguson technique had recurrences. The recurrence rate of 4.5 with this technique represents recurrence when it was employed in older patients. The number of patients in whom the McVay type procedure was employed was too small to be statistically significant, and the femoral recurrence rate represents only 1 case previously described.

We were interested in whether the recurrence rate was greater following simultaneous or interval repair of bilateral hernias. The figures obtained cannot be considered significant because of the obvious selectivity of the groups involved. In young patients with small bilateral defects, the tendency was to repair them simultaneously, while in older patients with larger defects and poor fascia, the repair was effected at intervals. In this light it is not surprising that the overall recurrence rate for simultaneous repair was 2.8 per cent while that for interval repair was 9.1 per cent. These data are inadequate to describe the influence of simultaneous repair upon recurrence.

There is considerable interest in the role of early ambulation upon the recurrence rate. Large control series are not available and the influence of selectivity renders the following and similar data statistically unreliable. Since nearly all indirect inguinal and femoral hernias were treated by early ambulation, while the policy on direct hernias was divided, the latter were chosen for analysis with regard to early ambulation. The overall recurrence rate for direct hernias was 5.0 per cent. The rate on one service where it was routine to keep patients in bed for 10 days following the repair of a direct inguinal hernia was 6 per cent. In a second group, where some patients were out of bed within 48 hours while others remained in bed from 7 to 10 days, the recurrence rate of those up early was 3.6 per cent and of those kept in bed 8 per cent. These are not comparable groups. The difference in results is felt to be more a reflection of fascial quality and defect size than of the effect of ambula-

tion. Available data did not seem, however, to indicate any increase in recurrence rate following early ambulation.

Numerous authors have called attention to the importance of the area lateral to the epigastric vessels in the recurrence of inguinal hernias as well as the floor of the inguinal canal medial to the epigastric vessels. Our data are in accord with previous findings. Sixty-eight and eight tenths per cent of our recurrences occurred through the direct area in Hesselbach's triangle medial to the deep epigastric vessels. Twenty-one and eight tenths per cent of the recurrences appeared lateral to the deep epigastric vessels at or medial to the internal inguinal ring. It was of particular interest that 9.4 per cent of the recurrences appeared lateral to the internal inguinal ring. The importance of adequate closure of the internal ring both medially and laterally, as well as reconstruction of the floor of the inguinal canal when needed, has been adequately stressed.

The 75 recurrent hernias treated during this period were analyzed for possible factors contributing to recurrence. The average weight of these patients was only 170 pounds. Only 8 per cent were over 190 pounds Thus obesity did not seem a predominant factor. Infection probably contributed to recurrence in only 8 per cent. Chronic cough was present in 21.3 per cent. Symptomatic prostatic hypertrophy was present in 13.3 per cent and chronic constipation was a complaint in 14.8 per cent. Twenty-eight per cent of these patients had returned to a physically active occupation. Only 1 recurrent hernia was encountered in a woman; this followed a pregnancy. Although one or more of these factors were present and may have played a role in individual cases, it did not seem possible to incriminate any one of them as a leading factor in recurrence for the group as a whole.

Fifteen or 1.4 per cent of these hernias were sliding hernias. Eleven of them occurred on the left side and 4 on the right. During this period these were all repaired by the inguinal approach alone, and there was a 55 per cent recurrence in this group. This fact emphasizes the importance of a combined inguinal and abdominal approach to this problem and we now manage all such hernias by the combined approach.

It was found that 5.2 per cent of these hernias were irreducible, 2.6 per cent were incarcerated, and 2.2 per cent were strangulated. Of the strangulated hernias, 12 were indirect inguinal, 6 were femoral, and 1 was a recurrent inguinal hernia. No strangulated direct hernia was encountered. It was necessary to resect bowel in 0.46 per cent; no recurrence followed in these cases. Richter's hernia was observed in 0.65 per cent of the cases, 5 of these femoral and 2 indirect inguinal hernias. In 2.9 per cent of the cases the herniorrhaphy accompanied orchidopexy; no recurrence was noted following these procedures.

DISCUSSION

It is believed important to stress the limitations of this and similar reviews. The inability to control numerous variables, the difficulty in obtaining 100 per cent follow-up examination, and the fact that many recurrences will not appear within 2 years make absolute conclusions from such a study invalid. Certain of the figures, however, are of interest and would seem significant. Apparently recurrences follow the repair of direct and indirect inguinal hernias in males often enough for it to remain a significant surgical problem. In this series the recurrence rate for indirect inguinal hernia 2 years following repair was 4.1 per cent and for direct inguinal hernias was 5 per cent. No one suture material, no one method, no one surgeon, was able significantly to lessen the recurrence rates. The recurrence rate following repair of previously recurrent hernias is high enough to consider the recurrent hernia an unsolved problem. In this series the use of fascial strips did not improve the results. A recurrence rate of 20 per cent or more in such hernias must be considered unsatisfactory. Recurrences in sliding hernias repaired by the inguinal route alone are high, and the combined inguinal and abdominal approach should be used for all such hernias. Recurrences in children, in females, in femoral hernias, and in males after orchiectomy are rare, and claims made for any suture material, particular type of repair, or surgeon, must be judged in the

light of this knowledge. Since we observed no femoral recurrence following either femoral or inguinal repairs, we do not believe that the use of the McVay procedure can be advocated strongly as a method of preventing femoral recurrence. Anatomical considerations, however, may well justify its employment in selected cases. The important questions of the role of early ambulation, of staged repair of bilateral hernias, and of many other factors, could be determined only by carefully controlled series of a large number of cases in which most of the many variables were kept constant. The quality of the fascial structures employed in the repair and the size of the defect are difficult to determine in review. More specific methods of classification of these factors and attention to their description in operative notes would be of advantage in further evaluation of results Nearly half of the recurrences were unknown to the patient, and were detected on examination. The questionnaire method, therefore, is highly unreliable in evaluating results of herniorrhaphy.

SUMMARY

1 One thousand and eighty-two herniorrhaphies performed at the Hospital of the University of Pennsylvania between January 1, 1945 and January 1, 1949 have been reviewed. The comparative incidence of indirect inguinal, direct inguinal, recurrent inguinal, and femoral hernias with regard to age, sex, and side of involvement has been analyzed.

2. The methods of treatment have been analyzed with regard to the type of repair employed, the suture material, the anesthesia, and the role of the surgeon in relation to the type of hernia, the age, and the sex of the patient.

3. The results of treatment have been analyzed on the basis of a 2 year follow-up examination.

4. The statistical limitation of this and similar reviews is stressed.

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PROSTATIC CANCER

IV. Combined Surgical and Endocrine Management of Curable Lesions

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WITH the development of curative surgery for prostatic cancer as described by Young almost 50 years ago, there appeared for the first time a more hopeful outlook for certain persons who have developed the disease. Although radical perineal prostatectomy has not been widely utilized in Europe, there has been a slow but steady increase in the number of American medical centers in which the operation is advocated. The advent of hormonal therapy for adenocarcinoma of the prostate gland has added a second powerful means of control available to the physician.

Although originally designed for application to tumors thought to be metastatic, both castration and the administration of estrogen—or a combination of the two—have in recent years been used for "curable" cancer as well. By the term "curable prostatic cancer" is meant that there is a microscopic diagnosis of adenocarcinoma which established the fact that there has not been extension of the neoplastic process beyond the genital fascial envelope (covering the seminal vesicles) and the anterior layer of Denonvilliers' fascia (composing the anatomical prostatic capsule of the posterior aspect of the gland). Inherent in this concept of curable cancer is the finding of a normal level of serum acid phosphatase activity and absence of any roentgenographic evidence of bony metastases.

It appears from the report of Jewett that the 10 year, cancer free survival rate of patients who were thought suitable for curative surgery (radical perineal prostatectomy) is such that at least some of the patients have been spared death by cancer. Relatively recently it has been brought out that castration, combined with the oral administration of diethylstilbestrol, not only provides symptomatic relief but prolongs the life of the prostatic cancer patient.

Without entering actively into the controversy which has been born of earnest advocacy of either radical surgery or hormonal control therapy, as the *only* type of therapy to be offered, it seems logical to point out that the two systems of treatment are not mutually exclusive.

If one admits that radical prostatectomy does completely eradicate some of the early cancers, one must also admit that an even greater number of lesions will not be entirely removed by the surgery. On the other hand, not even the most enthusiastic exponents of the hormonal control regimen are willing to cite their favored form of therapy as a panacea for prostatic cancer, although all agree that this kind of treatment is valuable.

From these simple considerations there has developed a program of combined radical prostatectomy and hormonal control therapy. This system was put into effect in the Division of Urology in the Francis Delafield Hospital, slightly more than 1 year ago. By utilizing a routine of evaluation for persons suspected of having a prostatic tumor, which includes frozen section biopsy of posterior prostatic tissue in each case, it is likely that earlier lesions are being detected. The finding of a curable adenocarcinoma, according to the definition of the term stated here, is immediately followed by radical perineal prostatectomy, bilateral orchiectomy, and the start of oral estrogen medication. Diethylstilbestrol at a dosage of 500 milligrams daily is given.

Since the adoption of this schedule for treating patients with apparently localized prostatic cancer, 40 have been started on the regimen. It has been gratifying to note that there have been no operative or postoperative deaths. In a 100 per cent follow-up it is found

From the Division of Urology, Francis Delafield Hospital, and the Institute of Cancer Research, Columbia University College of Physicians and Surgeons.

that all of the patients are still living, and that up to the present time there is no evidence of metastasis in any of the cases.

Surely, with the passage of time, there will appear an appreciable number of metastatic lesions in this group of individuals. Most probably, death will in some instances be attributable to prostatic cancer. However, there is reason to believe that the numbers of such therapeutic failures will perhaps be decreased from the cancer mortality statistics previously obtained by those who have relied entirely upon surgery or entirely upon hormonal control therapy as a means of management for "curable" adenocarcinoma of the prostate gland.

SUMMARY

1. The value of radical prostatectomy for curable adenocarcinoma of the prostate gland is emphasized.

2. The value of hormonal control therapy is similarly cited.

3. Therapeutic failures with each system of treatment are well known.

4. Combined surgery, estrogen therapy, and castration are suggested as a logical scheme for treating early prostatic cancer immediately upon microscopic confirmation of the clinical diagnosis.

5. Application of this therapeutic regimen in 40 consecutive cases of prostatic cancer is briefly noted.

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SUBCAPSULAR NEPHRECTOMY

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IN 1917 Dr. William Mayo, writing in the journal of SURGERY, GYNECOLOGY AND OBSTETRICS, gave his observations on subcapsular nephrectomy during two visits to European surgical clinics. He described the technique of this operation in such a masterly manner that the following quote from his paper seems most appropriate:

"In 1900 Dr. A. J. Ochsner and I saw Tuffier do a subcapsular nephrectomy. The opportunity to see this operation was alone worth the trip to France. In this country the mortality for nephrectomy in such conditions up to that time had not been far from 25 per cent. After exposing the kidney, Tuffier made an opening through the fibrous capsule down to the pyonephrotic sac and, with the hand, quickly decorticated the kidney. He then lifted it out from within the attached capsule which turned back about the pedicle (Fig. 3), placed a pair of clamps across the pedicle, cut the kidney away and packed the cavity with gauze. On my return I described this method, and I believe that subsequently subcapsular nephrectomy with the forceps treatment of the pedicle lowered the mortality of nephrectomy for pyonephrosis in America very materially. But the forceps method was clumsy and painful. It was possible, of course, by the use of catgut on a needle, to tie off the clamps, but if there had been soiling of the field there was danger that the needle and catgut passing through the pedicle might infect the vein. One patient in our series died from general septicemia which I believe had this origin.

"In May 1914, while on a visit to Petrograd, I saw that master surgeon, Federoff, make an addition to subcapsular nephrectomy which rendered the securing of the pedicle extremely easy. Drawing the kidney out of its capsule with a knife he separated the capsule from the sinus of the kidney as it was folded back over the pedicle. This allowed the kidney with the renal vessels to be drawn through the capsule, top and bottom, and made possible separate ligation of the vessels (2)."

Le Forte first described the operation in 1880. Ollier published a paper on subcapsular nephrectomy in 1886. The operation was reported by Tuffier in 1893. The evolution of the technique was thoroughly described by these eminent surgeons. The value of this old operation is emphasized by the fact that the indications, advantages, and techniques are thoroughly considered in all standard texts on urology.

The stimulus for writing this paper came from the fact that in observations in recent years of the numerous papers, exhibits, and motion pictures depicting both old and new operative procedures, no mention was made of subcapsular nephrectomy.

Difficulty in making adequate photographs and motion pictures may have been one of the reasons for the neglect of this valuable approach. Or perhaps its simple glamor has been eclipsed by such magnificent operations as thoracolumbar renal surgery, ureterointestinal anastomosis and cystectomy, and the exenterations and eviscerations.

Indications. Subcapsular nephrectomy is the operation of choice in removing kidneys densely adherent to the adjacent structures. In such cases the pedicle is shortened and the renal vessels imbedded in fibrolipomatous tissue making clamping and ligating very difficult. Frequent attacks of pyelonephritis, perinephritic inflammations, operations for recurrent calculi, advanced tuberculosis, and adhesions following renal trauma and gunshot wounds, are the principle causes of such adherent conditions. A few operations have been made necessary by unsuccessful pyeloplasty or nephropexy. Multiple operations for recurrent calculi usually associated with proteus or Pseudomonas aeruginosa infections, a previous nephrostomy drainage, or destruction of renal tissue by calculi and infections have been the indications for the majority of subcapsular nephrectomies.

The renal fossa following subcapsular nephrectomy for tuberculosis heals readily with the postoperative administration of streptomycin. However, this is not the operation of choice in renal tuberculosis, but may be necessary in advanced cases in which marked adhesions occur.

From the Urology Section, Walter Reed Army Hospital, Washington, D.C.

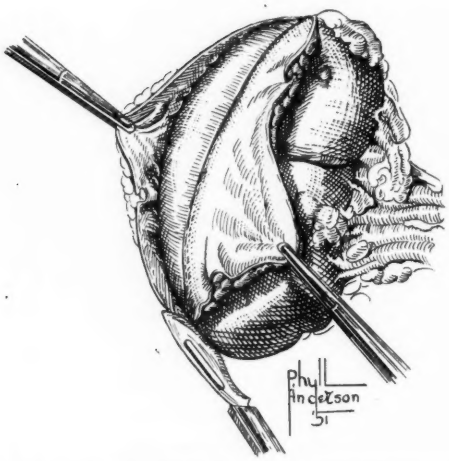

Fig. 1. Incision through capsule at convex border and beginning of decapsulation.

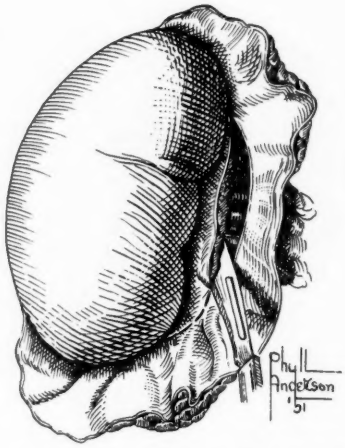

Fig. 2. Decapsulation completed. Beginning of incision of capsule reflected about renal vessels.

Malignancy is the only contraindication for subcapsular nephrectomy, in which case wide dissection of the perirenal tissues is necessary.

Advantages. The incidence of injuries to the adjacent structures—vena cava, intestines, adrenal, spleen and pleura—is greatly reduced. In this operation these structures are protected by the renal capsule. The chief danger lies in the possibility of accidents while isolating and clamping the pedicle, for at this time the vena cava or duodenum are the most vulnerable structures.

The renal parenchyma is removed completely with minimal tissue injury so that healing is usually prompt and very little tissue or lymph space is opened to invite the spread of infection. The operation can be accomplished quickly with a minimum of trauma, blood loss, or shock. The wound heals readily and convalescence is uneventful.

Technique of operation. The patient is placed in the usual position for renal surgery. The lateral position is employed, the leg on the table side is flexed at the knee and hip and the uppermost leg is approximately straight, thus tilting the pelvis to aid in widening the space between the costal margin and the crest of the ilium. The dorsal aspect of the patient should be 5 centimeters from the margin of the table in order to bring the field of operation nearer the surgeon. The kidney elevator should be beneath the costal margin so that the crest of the ilium is cleared when the elevator is raised. Additional space may be obtained by flexing the table—lowering the head and foot on the axis of the kidney elevator. The patient must be held firmly by straps or applied renal supports. A lumbar incision approximately 20 centimeters in length is made, beginning 3 centimeters above the level of the twelfth rib, 5 centimeters lateral to the spine, curving downward and forward along the inferior margin of the twelfth rib. The cicatrix of previous incisions should be removed and the incision carried far enough anteriorly to insure adequate exposure. The skin, superficial tissue, and scar are removed through the lumbar wall to expose the lumbar fascia or tissue overlying the kidney. The inferior aspect of the twelfth rib is exposed by retracting the muscles upward from the superior margin of the incision. Subperiosteal resection of the twelfth rib is done, cutting the rib close to the vertebra; rarely is it necessary to remove the eleventh rib.

The incision and exposure must be made at the kidney level because the kidney is fixed in position and cannot be drawn downward to a low incision. With adequate exposure attained, the tissue overlying the kidney is in-

cised and the renal capsule exposed. At this time, the degree of fixation of the kidney can be ascertained and the type of operation, subcapsular or otherwise, can be determined. The peritoneum is often densely adherent and identification is difficult. However, considering the previous observations and the urogram, the surgeon can usually determine prior to operation the type of surgery necessary.

If subcapsular exposure is decided upon, an incision is made in the renal capsule along the convex surface (Fig. 1). It is extremely important that the renal parenchyma is not torn, for if this occurs severe hemorrhage often results. Little hemorrhage, however, is caused by incising the capsule.

After the incision is made, the capsule is separated from the kidney by blunt dissection with the finger and reflected over the renal pedicle, carrying the peritoneum and diaphragm with the capsule attached. Adequate retraction is carried out with retained or individual retractors. The self-retaining costal retractors used in chest surgery often give excellent exposure. The capsule is incised about the renal vessels and pelvis at 1 centimeter margin from the renal hilus (Fig. 2). The incision may be made completely to encircle the pedicle, the vessels clamped en masse by one or two clamps (Fig. 3), and the pedicle divided and ligated proximal to the clamps (Fig. 4). However, this procedure is usually impossible because of the adhesions and the short pedicle, and it is often necessary to expose and ligate the vessels singly. The pelvis must be identified and avoided in ligating the vessels. After dividing the vessels, the kidney and the pelvis are drawn into the incision. The pelvis is dissected free and the ureter divided and removed with the kidney. The pelvis, however, is usually so densely adherent that it is not freed with the kidney, but requires separate dissection and removal. It is essential to remove the renal pelvis to prevent prolonged wound drainage from its lining epithelium. The renal pedicle is usually short, and great care should be exerted in order that injury to the vena cava and duodenum may be avoided.

In difficult cases with short pedicles, the clamp may be applied about the pedicle before the kidney is removed. This procedure allows better exposure and the capsular incision can be carried out proximal to the clamp and the vessels ligated separately.

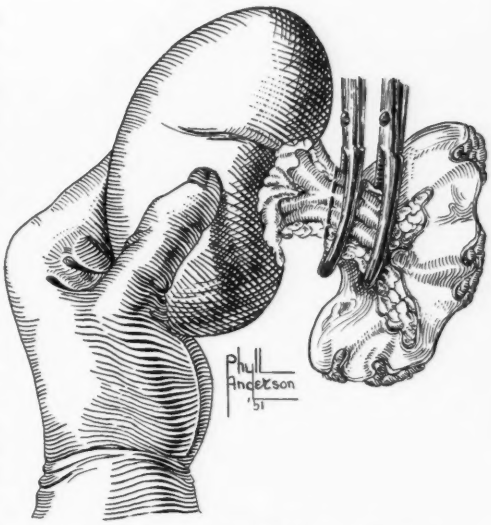

Fig. 3. Hemostats applied to renal vessels.

Ligatures placed about the pedicle enclosed in the capsule permit the vessels to retract and cause retrocapsular hemorrhage. In the event the pedicle is too short for incision of the capsule and ligation of the vessels, the clamp may be left in place at operation and removed on the fourth postoperative day. This is especially desirable in cases in which a segment of the wall of the vena cava has been caught in the clamp.

When advanced renal disease with friable tissue exists, the parenchyma may be removed by morcellation and the hemorrhage controlled by packing with gauze. The hemostatic pack may be removed after 4 to 6 days. Oxycel and gelfoam, held in place by heavy gauze packing, may be used in the depth of the wound. The morcellation procedure is safe because the tough renal capsule protects the vena cava, intestine, spleen, diaphragm, and other contiguous organs.

Throughout the operation great care is necessary so that injury to adjacent structures may be avoided. In placing the clamps, the

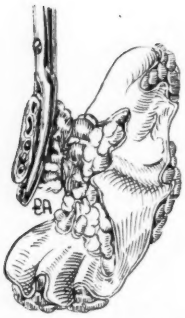

Fig. 4. Kidney removed by incising vessels between hemostatic clamps. Suture applied proximal to hemostat.

vena cava and duodenum are the most vulnerable structures.

After completion of ligation of the pedicle and removal of the pelvis, there should be a careful examination of the renal fossa and a thorough search made for possible injury to the peritoneum, vena cava, intestines, and other structures.

The wound should be closed with interrupted chromic gut sutures through all the deep fascia and muscles en masse and the skin closed with silk sutures. Two or three metal sutures—silver or tantalum—used as retention sutures, give a feeling of security against postoperative wound separation. A Penrose drain is left in place 24 to 48 hours. Endotracheal, Gwathmey's oil-ether, or spinal anesthesia may be used.

REPORT OF CASES

CASE 1. A 38 year old white male had a calculus removed from the right kidney in November 1939. He had a spontaneous passage of calculi from the left kidney in November 1947 and again in January 1949. In November 1950 an annual examination revealed albuminuria. An excretory urogram showed a large renal calculus in the right kidney. No treatment was instituted at that time, but in August 1950, because of dull flank pain, the patient was hospitalized for surgical removal of the calculus. He was well developed, slightly obese, and except for minimal costal vertebral tenderness on the right side, had no physical abnormalities. All parathyroid studies were within normal limits. On August 17, 1950, under endotracheal anesthesia, a right lumbar incision was made and the twelfth rib resected. An attempt to free the kidney was made, but the kidney was small, sclerotic, and densely adherent, making a pelviolithotomy or nephrolithotomy impossible or hazardous. The capsule was incised and separated from the kidney; the portion about the renal pedicle was then incised and the renal vessels exposed. One clamp was placed on the pedicle, the kidney removed, and the renal pedicle doubly ligated with No. 1 chromic catgut. On removing the twelfth rib an opening 2 centimeters in length was made in the diaphragm. This was closed after the kidney had been removed. The patient made an uneventful recovery.

CASE 2. A 33 year old white male had a urological study made as a result of an annual physical examination in 1947. At that time there were calculi in the pelves of both kidneys. Right and left nephrolithotomies were performed in January and again in April of 1948. Recurrent calculi were found in the left kidney during a follow-up examination in April of 1950. In July of the same year a left pelviolithotomy was done and a pyelostomy drainage tube left in place. The patient was then transferred to Walter Reed Army Hospital on August 21, 1950 where an unsuccessful attempt was made to change an incrusted pyelostomy tube. The stimulation resulting from this effort caused the patient to pass white faceted stones which had previously been revealed in the lower left ureter by excretory urography. He eventually passed 32 calculi, the largest being 1.5 centimeters in diameter, but he still had 2 calculi lying in the renal pelvis and 1 calculus in the renal fossa. On October 5, 1950, under endotracheal anesthesia, a left lumbar incision was made and the twelfth rib resected. There was dense scarring about the kidney pelvis. The kidney was small, atrophic, and complete mobilization could not be done. The capsule, therefore, was incised and the kidney separated from its capsule. The vessels were then divided and ligated individually. The densely adherent ureter and pelvis were isolated and ligated. The calculus in the renal fossa was located and removed. The wound drained a profuse green purulent material for 2 weeks. Culture analysis revealed the presence of Pseudomonas aeruginosa. Upon the patient's return from convalescent leave urinalysis revealed an occasional white cell and Aerobacter aerogenes as the infecting organism. The patient was treated with 14 grams of aureomycin after which the urine culture became negative.

CASE 3. A 39 year old white male was admitted to Walter Reed Army Hospital July 25, 1951 with a history of having passed renal calculi in 1944 and having had a right pelviolithotomy in November 1950. Renal colic recurred in March 1951 and an excretory urogram revealed 3 calculi in the right kidney pelvis, the largest being 2 centimeters in diameter. Moderate caliectasis was present. Differential phenolsulfonphthalein test revealed a delayed appearance time of 12 minutes from the right kidney. In order to remove the calculi, an exploration of the kidney was decided upon. On August 7, 1951, under endotracheal anesthesia, a right lumbar incision was made and the twelfth rib resected. Because the kidney was found to be densely adherent it

was impractical to mobilize the kidney in the usual extracapsular fashion. The renal capsule was incised, and with the index finger, a subcapsular lysis was carried out and the capsule folded down over the renal pedicle. The renal pedicle vessels were then clamped individually, divided, and ligated. The renal pelvis was dissected free and the ureter clamped and ligated. Two Penrose drains were left in place and the wound healed per primam with a minimum of drainage.

CONCLUSIONS

Subcapsular nephrectomy is a valuable procedure and is the method of choice in removing kidneys densely adherent to the adjacent tissues.

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FRACTURES OF BOTH BONES OF THE FOREARM IN ADULTS

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A REVIEW of leading textbooks published in the last decade shows that treatment of fractures of both bones of the forearm by closed reduction is still being stressed for adults as well as for children. Perhaps this teaching arises from the prevalence of forearm fractures among children, where nonoperative treatment deserves emphasis. Their weaker musculature makes reduction easier than in adults and also decreases the tendency toward subsequent slipping. In children, also, osteogenesis is so active that the danger of nonunion hardly exists. Furthermore, with growth, children's bones tend to correct minor discrepancies of alignment. Among adults, however, these factors are reversed; and the results of conservative treatment often prove so disappointing that the opposite rule seems to apply. Open reduction is indicated in the majority of cases.

Special study has been devoted to this topic on the Orthopedic Service of The Boston City Hospital during the last 3 years; and a series of 23 such cases is presented in the following report. A high proportion of failures resulted from our closed manipulative reductions, in spite of conscientious effort to obtain and to hold good closed position. In our series of 23 cases successful reduction was obtained by closed manipulation in 12, in 7 of which the reduction slipped in plaster within 3 weeks. Unsatisfactory reduction by closed manipulation resulted in 7 cases. In 4 instances closed reduction was not attempted; open fracture permitted operative fixation in 2 of these. By an older standard some of these "failures" might be judged "satisfactory"; but experience has demonstrated the importance of very accurate reductions in order to restore normal rotational movements of the forearm. We are no longer able to accept with complacency the displacements of the radius which formerly seemed "good enough." Papers by Patrick in 1946, and by Knight and Purvis in 1949 have stressed this point very clearly. In our series we found that open reduction was required in 74 per cent of the cases in which closed methods had been tried.

In order to improve treatment, we believe that surgeons must reorient their attitude toward these fractures. (1) In the small number of cases in which closed reduction may be applicable, the standard requirements for manipulative treatment must be clearly understood. (2) Surgeons must especially cultivate their judgment for recognizing types of fractures that are bound to fail under closed treatment. (3) Unnecessary delays of closed methods should be avoided by acting early on the indications for operative treatment. Finally, the various operative procedures should be appraised from the standpoint of simplifying them, or making them more reliable. Each of the above points deserves special consideration.

From the Orthopedic Service, Boston City Hospital, and Post-Graduate Fracture Department, Boston University School of Medicine.

CONSERVATIVE TREATMENT

It may seem elementary to state that the success of closed manipulation depends on three essential conditions: adequate anesthesia for complete relaxation; convenient x-ray control; and, a well chosen and carefully applied method of retention. This is not the place to dwell on basic principles, but it may be helpful to comment briefly on our own experience in regard to these three particular requisites. The mechanical difficulty of reducing two fractures at once may be compared to a toy puzzle in which one bone is pried loose whenever the other is replaced. It is useless to attempt this feat in the presence of active

muscle spasm or when muscle contraction has developed following prolonged overriding. Spasm cannot be successfully eliminated by "primary" anesthesia such as nitrous oxide, or local injection of novocain. Brachial plexus block is highly satisfactory in special hands; or failing this, a full, surgical anesthesia with deep relaxation is required. Delays in attempting reduction are so apt to lead to contractures and "fixed spasm" that immediate reduction within the first few hours should be a standard rule whenever possible. When later reductions are attempted, the muscles must be pulled heavily; and manual traction, even by two strong operators, is seldom sufficient. In the past, we have used the Soutter traction, as suggested by J. A. Key; but this apparatus carries danger of neurocirculatory damage, and we do not now favor its use. The disadvantage with all mechanical measures, apart from the real possibility of soft tissue injury, is that when such heavy pulls are needed for reduction, the tendency toward slipping after reduction is greatly increased. In such cases we believe that open methods will prove more certain of success and less damaging.

Since these fractures are surrounded by the upholstery of muscle padding as well as edema and hemorrhage, palpation can seldom be relied upon to judge the adequacy of reduction. Manipulation will often fail if x-ray control is not easily accessible. Our plaster room has been equipped with the latest model fluoroscope; but we believe that its use is altogether too dangerous in routine cases. We depend on portable films; and if these are not available, we feel that the chances of success from closed manipulation are distinctly curtailed. It may be said that no fair trial of closed reduction can be carried out unless accessible x-ray control is available.

Even after successful manipulation, the greatest cause of failure lies in the inadequacies of retention. Of course, a firmly molded cast must be applied from the palm of the hand to the middle of the upper arm. Some years before this study was started, we used pencil-like pressure between the radius and the ulna, as suggested by Böhler; but it did not prove effective in our hands. The cause of slipping lies in the intrinsic muscle pulls acting on oblique or comminuted fracture surfaces, or it may arise from disregard of rotational muscle strain. This topic has been so well discussed by E. M. Evans that readers should refer to his article; but even with good positioning, our cases have shown a tendency to slip. This procedure requires close x-ray follow-up for at least 3 weeks. The use of continued traction in bed undoubtedly has merit in some cases; but we have not used it in this series because it so often leads to disappointments, prolonged delay in union, and imperfect alignment.

Although the results of conservative treatment have proved particularly discouraging in the present series of cases, we would not suggest routine adoption of operative procedures. Our practice on the Orthopedic Service has been to attempt closed reduction in all cases in which success seems reasonably possible; and not until this treatment fails do we advocate open methods. Statistical studies such as this often yield erroneous impressions, and the value of conservative treatment may well be considerably higher than this review of cases would indicate.

OPERATIVE PROCEDURE

If conservative procedures fail, reliable operative procedures must be developed to replace them. In the past, the disadvantages of open surgery for forearm fractures have arisen from certain mechanical and technical defects. Briefly, these have consisted in four objections: (1) the danger of surgical infection, which is still a potentiality, even though diminished by the use of antibiotics; (2) the high incidence of nonunion following boneplating; (3) the prolonged surgical trauma involved in fixing each of the two bones, which amounts to two operations, rather than the one; (4) the less common, though always possible chance of cross union, especially when one common skin incision is used for approaching both fractures.

These dangers have been well summarized by Evans as arguments for conservative treatment. He quotes the study by Holdsworth which reports 9 per cent nonunion and 4 per cent infection in a series of 85 cases. Knight

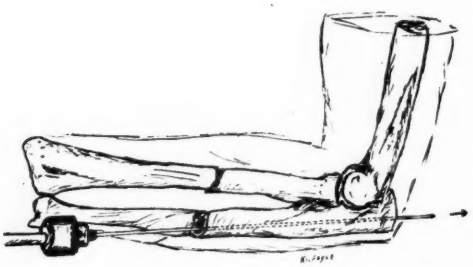

Fig. 1. Introduction of wire in proximal shaft of ulna.

and Purvis reported an even larger ratio of nonunion, amounting to 4 out of 20 cases. Evans also cites some of the bad operative complications which every good surgeon must bear in mind; notably, the danger of injuring the posterior interosseous nerve, the ischemic paralysis that could follow use of a tourniquet, and the increased hazard of cross union resulting from surgery.

As a means of overcoming these objections, we have endeavored to simplify the operative technique. We have eliminated the danger of ischemia by operating without any tourniquet. We have lessened the danger of cross union by insisting on two, separate skin incisions in approaching the two fractures. We have adopted some of the principles suggested by Lambrinudi in 1939 for intramedullary wiring of the ulna, and have added the recommendation made by Hermann in 1943, that a bone graft should routinely accompany every form of internal fixation of forearm fractures. We prefer autogenous splinters of iliac bone for this purpose; but we have also often used bone bank bone. Since intramedullary wire fixation of the radius is technically more difficult to carry out, and leaves a possibility of rotational instability, we prefer to plate and graft this bone in combination with intramedullary wire fixation and grafting the ulna. We call this "the combined method."

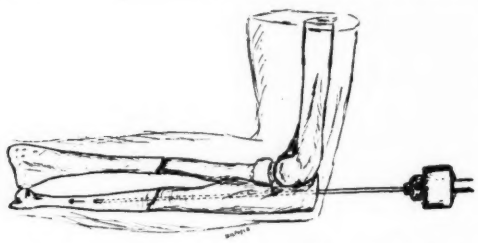

Fig. 2. Wire drilled into distal medullary canal of ulna.

The procedure is relatively simple. It begins with brachial block anesthesia. A 2 inch to 3 inch incision is then made over the ulna at the fracture level. As the bone is subcutaneous over its whole length, this point can be accurately determined by palpation. The proximal fracture end is then drawn out of the wound, enough to allow a 3/32 inch stainless steel Kirschner wire to be threaded up its medullary canal. This is done in a retrograde manner; that is, with the point of the wire aiming upward (Fig. 1). It is then drilled through the olecranon and projects from the elbow. After reducing the fracture, the blunt end of the wire is drilled down the medullary shaft of the distal fragment to within 1/2 an inch of the wrist joint (Fig. 2). It is sometimes necessary to use an 11 inch wire in order to have adequate length. The splinters of bone graft are laid around the fracture, being careful to avoid the interosseous surface. The muscle layer is then closed firmly over the splinters so that they will hug the bone. This completes the ulna portion of the operation in a manner requiring not over 20 minutes of operating time. Bone plating and grafting is carried out for the radius in a routine manner through a separate skin incision (Fig. 3). We strongly recommend Henry's approach, though on occasions, we have used others. As in the ulna, care must be taken to avoid placing bone grafts along the interosseous aspect of the radius for fear of promoting a cross union. In some cases, we have not fixed the radius with plating, but have substituted intramedullary wiring here, as well as in the ulna.

We have found it necessary to use wires of 3/32 inch diameter since any smaller size is too pliable to hold the fracture securely. However, at this gauge, the wire does not bend easily enough to permit its introduction obliquely through the distal shaft of the radius, as Lambrinudi had recommended for lighter wires. Therefore, when we wire the radius, we have adopted the procedure advocated by Appollonio and Peterson which they employed successfully on a series of cases at the Chelsea Naval Hospital in 1943. A small skin incision

is made in the anatomical snuff box over the distal end of the radius. The wrist is then flexed and deviated ulnarward as much as possible, and the wire is allowed to enter the radius through the region of the styloid, on a line almost parallel to the axis of the bone (Fig. 4). Care must be taken to avoid the extensor tendons of the thumb. The wire can then easily be threaded up the medullary canal which will guide it to the fracture site. An adequate incision is required over the fracture itself to facilitate a good reduction here and to aid in guiding the wire across the fracture line and into the proximal shaft. Even a very high fracture, in the region of the bicipital tuberosity can be reached in this way, when it would not be accessible for plating. This method is especially effective when a double fracture of the radius is present, or in a compound wound where a hurried procedure is desired. Knight and Purvis have already discussed a technique essentially similar to this.

The drawbacks about this method are first that wire is apt to cause irritation around the wrist joint, which may prove annoying; and also, light wire does not fully stabilize the radius whose anatomical position is so very important to the function of rotation. Further, since there is a normal curvature to the shaft of the radius, this bone does not accommodate itself to heavier wire. Nevertheless, this method of intramedullary wiring is well worth remembering in special cases; and when we have used it, no serious difficulty has ever resulted.

Postoperatively, a cast is applied from below the axilla to the palm. The projecting end of the ulna wire and the radial (if there is one) may be incorporated in this plaster; or if preferred, the wires may be cut off subcutaneously and covered over by skin. Wires should be removed as soon as roentgenograms show development of callus—a period of 5 to 7 weeks or more. Even after the wires are withdrawn, plaster protection must be maintained until union is solid.

RESULTS AND COMPLICATIONS

In our series of 18 operative cases, 12 have been done by the combined method of plating

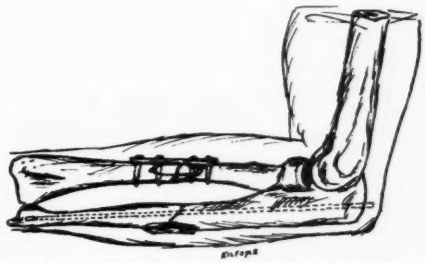

Fig. 3. Radial plate and bone grafts in place.

the radius and wiring the ulna; 2 by double wiring with intramedullary fixation of both radius and ulna; 2 by single wiring of the ulna alone, when the radial fracture seemed very stable after ulna fixation. We believe, however, that it is usually unsafe to rely on the stability of either fracture as a routine. We have known of instances in which, for lack of internal fixation, the fracture ends have slipped in the process of closing the wound or applying the plaster. It will be too late to add internal fixation, and a subsequent surgical procedure may be required. In almost all our cases we have used bone grafts on both bones. We have followed all the cases past the stage of bone healing, and most of them for a minimum of a year. We have not found any satisfactory criteria to establish a date of healing, so that we offer no statistical data on this point. It can be said that this operative procedure does *not*, in our experience, *hasten* healing. The majority of our cases require from 8 to 12 weeks after operation before the fractures are really solid—and sometimes much longer. None of our cases operated upon have resulted in nonunion, a fact which we attribute largely to the use of grafts.

Three of our patients were adolescents in their midteens; repositioning could not be maintained by closed methods in their case. Early closure of the olecranon epiphysis resulted from the pinning, but this did not detract from a thoroughly satisfactory clinical

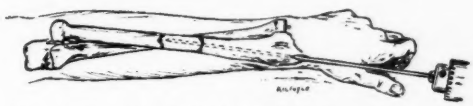

Fig. 4. Insertion of wire into radius through the wrist.

end result. However, it would be unwise to use this method on younger children.

Perhaps the most important part of a study like this lies in reporting the complications that develop. These reveal possible errors to be avoided and show inherent weaknesses of the method. Among 18 operative cases, 2 infections developed; one superficial and the other deep. Both cleared up without serious sequellae. In one case, the wire in the ulna was poorly selected without checking on the quality of its metal which later proved not to be stainless steel. An electrolytic reaction developed, causing aseptic necrosis of the cortical bone. This cleared up after the pin was removed, and solid union was obtained. The ulna wire was pushed too far in another case, and it gradually eroded through the end plate of bone. When the wire was withdrawn, the lesion healed without disability. Another case came to our attention, which, although it was done a year before this study was started may be mentioned as a warning. Graft splinters were laid too close to the interosseous ligament across the space between the bones. Cross union developed solidly. In the present series no other complications developed except for the 4 instances listed.

Excellent alignment has been maintained in all our cases; and in all, the patients have regained satisfactory ranges of wrist motion after the fractures have healed.

SUMMARY

1. Comparison of conservative and operative methods of treatment for fractures of both bones of the forearm in adults shows that operative treatment is usually necessary. A study of 23 cases is presented.

2. A "combined method" of operating with intramedullary wire fixation of the ulna and plating of the radius together with grafts to both fractures is recommended and discussed.

3. Follow-up results on a series of 18 operative cases are encouraging.

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EDITORIALS

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FEBRUARY, 1953

THE PREOPERATIVE COUGH

CONSIDERATION has shifted during recent years, and rightly so, from merely the treatment of postoperative complications to their prevention. This is evident in the emphasis placed on preoperative preparation of the debilitated patient relative to electrolyte imbalance, anemia, dehydration, hypoproteinemia, nutritive deficiencies, and other conditions which are recognized as hazards to a rapid and uneventful postoperative convalescence. Likewise, certain preventive measures are routinely employed to reduce the possibility of thromboembolic complications during the postoperative period. Although the adequacy and satisfactory status of the circulation, hepatic and renal function, and other important physiologic processes are now commonly evaluated and, if necessary, improved prior to operation, it appears that frequently the pulmonary status may receive insufficient consideration prior to the usual type of abdominal operation.

It is true that if there is a question of tuberculosis, asthma, bronchiectasis, acute respiratory infection, pronounced chronic bronchitis, or other clearly recognized organic pulmonary disease that these conditions are thoroughly studied and given adequate consideration before an abdominal operation is undertaken. In addition to such well recognized states of definite pulmonary disease, however, there is an equally definite clinical entity which may lead to postoperative pulmonary complication and which may be overlooked. Reference is made to the chronic productive cough, which is of especially frequent occurrence among those who smoke a great deal. Usually this is most pronounced in the mornings and is more or less taken for granted by the patient, with the result that if he is asked if he has any cough, he frequently will reply in the negative. Likewise, a roentgenogram of the thorax may not give evidence of anything abnormal and results of physical examination of the thorax commonly are essentially negative. On the other hand the simple routine expedient of asking the patient to cough reveals to the attentive ear considerable secretion in the airways and on closer questioning the patient admits or remembers that he does cough and expectorate a moderate number of times each day. Although this is done under ordinary circumstances scarcely with any notice, such is not the case after an abdominal operation. At this time coughing is painful and therefore restricted. The obvious result is that the unexpelled secretions accumulate and atelectasis may result.

From experience of the last few years it has been learned that if, along with certain other routine preoperative questions, the patient is

asked to cough, information of value can be obtained. This is especially true if the patient smokes. If the cough is dry and completely unproductive, atelectasis or other pulmonary complication need not be feared as a complication of an abdominal operation under ordinary circumstances. On the other hand, if the cough produces obvious evidence of moisture and secretion within the airways, preoperative preparation to reduce the necessity of postoperative cough, and virtually to eliminate the chance of postoperative atelectasis, is advisable. At least one routine preoperative preparation which gives satisfactory results includes: complete elimination of the inciting factor (smoking) for 3 or 4 days or longer prior to operation, administration of an expectorant mixture, inhalation of nebulized penicillin or some comparable form of treatment and adequate humidity, generally supplied by one or more steam kettles. Preferably this treatment is administered in the hospital although, for financial or other reasons, this may not always be feasible. Similar treatment is continued during the postoperative period.

During the last few years, where these measures have been utilized, postoperative atelectasis and pneumonia after abdominal operation, in the otherwise uncomplicated case, have virtually disappeared. The simple practice, therefore, of asking the patient to cough at the time of surgical consultation, and heeding what is detected by the ear at ordinary conversational distance, rather than relying entirely on the roentgenogram or the stethoscope, will yield rewarding dividends. Appropriate preoperative measures not only reduce to a minimum the possibility of postoperative pulmonary complications such as pneumonia or atelectasis but, in addition, eliminate both the pain associated with early postoperative cough and unnecessary stress on the abdominal incision. JAMES T. PRIESTLEY.

THE MEDIASTINAL SHADOW

TO the anatomist, the mediastinum is the "interpleural space" or that portion of the thoracic cavity bounded by the sternum, the thoracic vertebrae, and the pleura of each lung. In it are contained all the thoracic viscera except the lungs. To the roentgenologist, the mediastinum is a shadow made up of many components, including the shadows cast by the thoracic viscera except the lungs, and by the sternum, the vertebral column and its adjacent soft tissues.

Twenty-five years ago, few surgeons would undertake an exploration of the mediastinum. It was thought that most of the tumors which occurred there were malignant and inoperable. It was not important, therefore, to make an accurate preoperative diagnosis in the case of the mediastinal tumor or to distinguish between a tumor and an aneurysm. Today, with operations on the thorax an everyday occurrence, and with surgeons willing and able to operate even upon the heart and aorta, it is important that the preoperative diagnosis be as accurate as possible.

Abnormalities of the mediastinal shadow may indicate disease in the cardiovascular system, the gastrointestinal tract, the respiratory system, the thoracic cage, the lymphatics, the nervous system, or certain of the endocrine glands. Is it any wonder, then, that the roentgenologist finds it difficult to make an accurate diagnosis of the cause of an abnormal shadow? Yet this diagnosis depends largely upon an intelligent interpretation of the roentgenologic findings. Additional information may sometimes be obtained from the history, from cytologic and bacteriologic examinations of the sputum, and from the results of endoscopic examination.

An adequate roentgenologic examination of the mediastinum must include a lateral view.

In addition, it is good practice to employ roentgenoscopy and to give the patient a swallow or two of barium. Further information can be gained in some cases from roentgenograms of the thoracic portion of the spinal column, from views made in the oblique or lateral recumbent positions, or by the use of the special techniques of tomography and angiocardiography. All the films and fluoroscopic observations are obtained to supply data relating to the following factors:

1. The location of the lesion. Certain tumors are more common in the anterior portion of the mediastinum, while others are seldom found except in the posterior portion. Some lesions extend superiorly into the neck, while others are always adjacent to the diaphragm.

2. The appearance of the lesion. The tumor may be round, oval, lobulated, sharply circumscribed, or poorly defined. The shadow may be dense or relatively translucent.

3. The presence of calcification. Calcium may be deposited in the center of the mass or around its periphery and it may be punctate or linear in character. In rare instances a bone or a tooth may be seen.

4. Involvement of the bony thorax. Some tumors cause erosion or invasion of a rib or a vertebra. It is important to determine the location of involvement.

5. The presence of pulsation. This may be transmitted from an adjacent structure or it may be expansile in nature.

6. Attachment to the trachea.

7. Displacement of the trachea, the esophagus, the heart, or any of the other mediastinal structures away from their normal position.

8. The presence of a fluid level, which may be between air and fluid or between two types of fluid with different specific gravities.

Correlation of these data with the information supplied by the clinician and endoscopist will usually give the surgeon sufficient information on which to base his decision and plan his attack. With all the information which can be obtained, it may still be impossible to predict the histologic nature of the lesion causing the abnormal mediastinal shadow. The tumors occurring in the mediastinum have much in common with regard to their roentgenologic manifestations. Frequently, however, some characteristic feature may be found which allows a definite diagnosis.

For example, the neurogenic tumors which are among the commoner lesions of the mediastinum are found for the most part posterior to the esophagus. Almost half of them involve the bony thorax by erosion of a rib or thoracic vertebra. Approximately 15 per cent extend along a nerve root into the spinal canal and possess both an intraspinal and an intrathoracic portion. It is usual, in such a case, to be able to demonstrate erosion and enlargement of the intervertebral foramen. The intraspinal portion invariably produces symptoms indicative of compression of the spinal cord. Neurogenic tumors seldom calcify.

Teratoid tumors, including both the dermoid cyst and the teratoma, almost always are to be found in the anterior portion of the mediastinum. There is roentgenologic evidence of calcification in about half of them. Identification of a tooth in the mass is pathognomonic. When a dermoid cyst erodes a bronchus and discharges its contents into the tracheobronchial tree, the patient coughs up sebaceous material or hair and the roentgenogram shows an air-fluid level in the tumor.

Other cysts which develop in the mediastinum include the bronchogenic, enterogenous, and pericardialcelomic varieties. Two thirds of the celomic cysts are located in the right cardiophrenic angle anteriorly. In this position, they must be distinguished from hernias through the foramen of Morgagni, as well as from other tumors. Cysts of the bronchogenic

and enterogenous varieties may be attached to the trachea or esophagus and displace or deform these structures. Tracheal attachment can be demonstrated at the time of roentgenoscopy if the mass moves upward when the patient swallows. Esophageal attachment is shown by giving the patient a swallow of barium and noting displacement or deformity of the lumen of this structure.

Thymomas are always found in the anterior portion of the mediastinum. Although they are usually situated near the base of the heart, they may occur at any level between the diaphragm and the clavicles. Fifteen to 20 per cent of them show roentgenologic evidence of calcification. Three fourths of all thymomas have been found in patients suffering from myasthenia gravis, and 15 per cent of patients suffering from this disease have been shown to have a thymic tumor. While the majority of these tumors are apparent on the usual frontal roentgenogram, it is interesting that 40 per cent of them cannot be seen on this view. It is necessary, therefore, to include a lateral roentgenogram and a fluoroscopic examination in the study of a myasthenic patient. The presence of an anterior mediastinal mass in a patient suffering from myasthenia gravis is pathognomonic of thymoma.

Recognition of an aneurysm of the aorta, innominate artery, or pulmonary artery depends upon the demonstration of expansile pulsation. Since only about a fourth of all aortic aneurysms show characteristic expansile pulsation, it is frequently necessary to employ the procedures of angiocardiography or aortography to demonstrate that the lesion is a part of the vascular system.

The dilated esophagus of achalasia, herniation of the stomach through the esophageal hiatus, and primary tumors of the esophagus can all be recognized after the patient has taken a few swallows of barium.

Approximately a tenth of all thyroid adenomas arising in the neck extend into the thorax in a substernal position. These tumors are attached to the trachea and show upward motion on deglutition. Calcium is frequently present. These tumors are usually recognized for what they are, for the mass obviously extends down from the neck into the thorax and almost always displaces the trachea away from its normal position. Occasionally a mediastinal mass which shows no evidence of extension downward from the neck or upward into the neck proves to be a thyroid adenoma. The majority of these tumors are situated in the anterior portion of the mediastinum. Many of them show evidence of calcification. A history of a previous thyroidectomy can be obtained from about half of these patients. In some instances the adenoma may take up radioactive iodine and allow identification in this manner.

Diseases of the lymphatic structures in the mediastinum, such as the lymphomas, Boeck's sarcoid, and tuberculosis, are usually associated with lymphadenopathy elsewhere in the body. Biopsy of a superficial lymph node will establish the diagnosis. These lymphatic diseases commonly involve the lymph nodes in the roots of the lung, in addition to those in the mediastinum.

From this brief review, it can be seen that much can be learned by an intelligent study of the shadow cast by the mediastinum on the roentgenograms of the thorax. Sometimes identification of the histologic nature of the lesion is possible. At other times the only point determined with certainty is that the lesion involves the gastrointestinal tract or the cardiovascular system. At all times it should be possible to determine accurately the location of the mass and in most cases to predict whether or not it is possible to treat it surgically.

C. Allen Good.

THE SURGEON AT WORK

SIGMOIDOSCOPY

A New Surgical Position and Apparatus for Attaining and Maintaining It

LYMAN C. BLAIR, M.D., Houston, Texas

BECAUSE of long dissatisfaction with the customary positions used for sigmoidoscopy, a new position for this procedure has been devised.

This position might be most simply described as a modified knee-chest position. The modifications consist of separation of the knees and acute flexion of the lower extremities at the knees. Separation of the knees is necessary to allow maximal relaxation and working space in the pelvic outlet. Acute flexion of the lower extremities at the knees is necessary, I believe, to maintain a stable and comfortable position. By this latter maneuver, one "locks" the knee as a wrestler locks a joint, and is thereby able to obtain good control of the femur (the strongest and best padded bone in the body).

Special apparatus is necessary for the maintenance of such a position for which a pair of devices which I call "leg wells" has been made (Fig. 1). The major components are two tapered trough-like pieces of heavy sheet metal (16 gauge stainless steel) which are welded together at a 30 degree angle. These are reinforced at the bottom with a yoke of heavier steel and supported on a swivel. A 5/8 inch steel rod, bent into an S curve, completes the device.

These leg wells are to be mounted in the sockets of examining or operating tables, which are made for stirrups or Bierhoff crutches. The patients are positioned as shown in Figures 2 and 3.

Conscious, co-operative patients without arthritis can easily get themselves in this new position. They simply get upon the table on their hands and knees, and then put the knees into one well at a time.

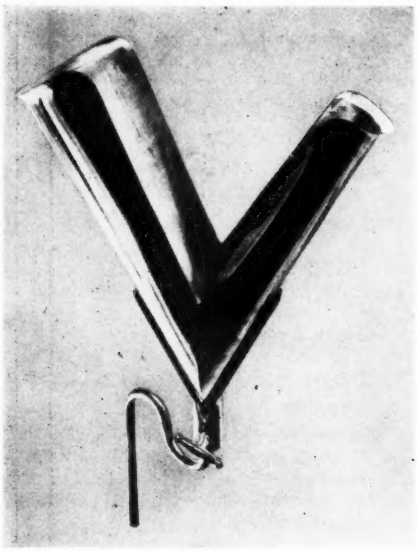
If general anesthesia is to be used, it is best to start the anesthetic with the patient in the usual position. A double tackle or electric hoist should be attached securely to the ceiling. When anesthesia is established, the patient is rolled over, and a heavy webbing band is passed under his lower abdomen. The band is attached to the tackle or hoist, and the patient's buttocks are raised about 18 inches. Then his knees are positioned over the respective wells, and the patient is lowered.

Some of the advantages of this new position are:

1. The knees are well separated, allowing maximal relaxation and working space in the tissues of the pelvic outlet.
2. The position is stable and comfortable.
3. No external pressure on any part of the abdomen is necessary; therefore, a negative pressure prevails in the pelvis, and the abdominal viscera tend to roll cephalad. Also, the hollow viscera in the pelvis easily distend with air at atmospheric pressure.
4. The physician may approach his patient axially; he does not have to work "around a corner."

Some disadvantages or contraindications are:

1. Patients with a low cardiac or respiratory reserve should not be placed in such a position.
2. Patients with severe arthritis or deformities may not be able to assume this position.
3. In this position, any manipulation which might open a vein at a level higher than the heart could lead to air embolism. Theoretically, this could even travel up the vertebral veins and involve the brain. (Actually, I believe that the danger is slight.)
4. In obese persons undergoing lengthy procedures, the circulation in the lower legs might be embarrassed because of the acute flexion at the knees. However, anyone of near normal weight and possessing normal joints can flex the knees to an angle much more acute than the 30 degrees which has been built into my leg wells.



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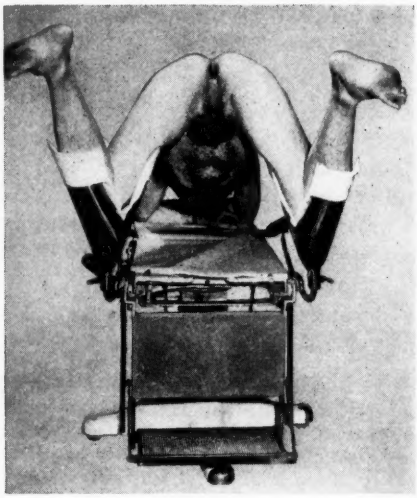

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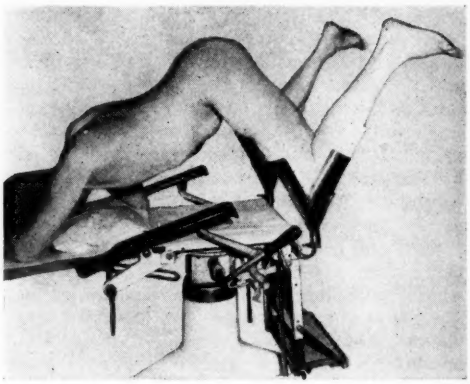

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Fig. 1. Photograph of a leg well.
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Although this position and the leg wells have been devised for sigmoidoscopy, the apparatus should be useful for other examinations and operations in the region of the pelvic outlet, such as culdoscopy, air cystoscopy, colpotomy, and operations on the posterior urethra or prostate.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE transactions[1] of the 25th meeting of the Northern Surgical Association, presented at the 1951 summer meeting in Copenhagen, cover a wide field of surgery ranging through practically the entire field of thoracic and abdominal surgery, surgery of the neck and extremities, and include especial emphasis on three main topics: surgery of the hand, carcinoma of the breast, and the treatment of hemorrhoids, anal fissure, fistula in ano and anorectal prolapse. Except for the discussions upon the main topics the papers are brief and concise, rarely more than 3 or 4 pages in length, with the advantage that the reader can quickly grasp the writer's point of view, and the further advantage for the American surgeon that all the papers are in English. A list of some of the titles, "Follow-up Examinations of Thoracoabdominal Operations for Carcinoma of the Stomach" by Aanesen of Oslo, "Surgical Treatment of Achalasia of the Esophagus" by Malm of Malmö, "Observations from 800 Goiter Operations" by Lundgren of Örnsköldsvik, "Surgical Treatment of Mitral Stenosis" by Prip Buus of Horsens and Husfeldt of Copenhagen, and "Preliminary Results of Resections Undertaken for Pulmonary Tuberculosis" by Holst of Oslo, indicates the wide range of subjects under discussion.

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It is difficult to summarize in a few paragraphs the very excellent and comprehensive discussion of the whole problem of breast cancer as it is presented in these reports. They contain a careful summary with numerous statistical tables of the results that have been obtained in three different clinics, those of E. Dahl-Iversen of Copenhagen, of H. Rosenqvist of Stockholm, and of Jens Nielsen of Copenhagen.

[1] TWENTY-FIFTH MEETING OF THE NORTHERN SURGICAL ASSOCIATION. Held in Copenhagen, June 27 to 29, 1951; Official Transactions. Edited by Prof. E. Dahl-Iversen, M.D. Copenhagen: Ejnar Munksgaard, 1951.

Dahl-Iversen begins his paper with the statement, "Carcinoma of the breast is no good form of cancer," and with that statement there can certainly be no disagreement. He compares the results of untreated cancer with the results of surgical treatment in clinics in different parts of the world, discusses very fully the pitfalls involved in the classification of carcinoma of the breast in stages, the question of operability, particularly on the basis of Haagensen's criteria, and McWhirter's plan of limited excision followed by intensive radiation therapy.

Dahl-Iversen's method of approach in recent years has involved abandonment of preoperative radiation treatment and more radical surgical intervention, with extension of the operation to include removal of supraclavicular and parasternal lymph nodes. "In preventive removal of the supraclavicular lymph nodes in 98 cases M. Andreassen and Dahl-Iversen, in 1949, found microscopical lymph node metastasis in 17 per cent of the cases, but in no case of microscopically absent metastasis to the axillary glands." In the past 9 months removal of the parasternal lymph nodes in 57 successive cases was carried out as a part of the radical operation. In 47 of these lymph nodes could be demonstrated microscopically, and in 13 of the 47 microscopical metastases were found. The relation of lymph node involvement to the site of the primary tumor, the variable lymph node involvement in axillary, supraclavicular and parasternal locations, the normal localization of parasternal lymph nodes (Stibbe) are all carefully considered on the basis of the author's findings and of world surgical literature. In concluding his opening remarks the author says "We have commenced an examination of the lymphatic system in carcinoma of the breast after injection of 'Niagara skyblue,' an intensely staining blue stain which we inject 24 hours before the operation under the papilla and into each of the four quadrants in a concentration of 2 per cent. At operation the lymph nodes are seen stained an intense blue, and the lymph vessels appear as blue cords. . . . Whether it will be of any importance, we do not know yet, but we have found both metastatic and non-metastic lymph nodes stained blue, but it looks as if they do not stain when they are completely filled with metastases. . . . This staining method has made it much easier to find the supraclavicular and parasternal lymph nodes. . . . It has been amazing to see the swarm of minute blue nodes found in the axillary fat."

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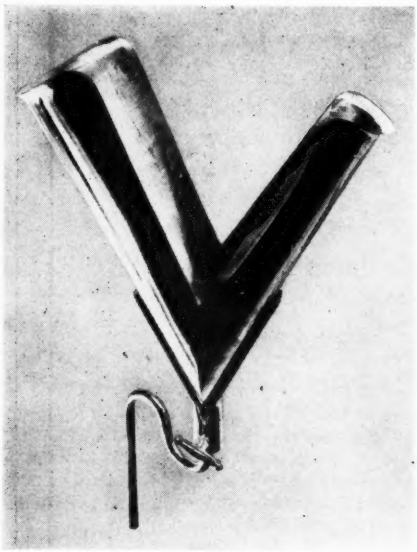

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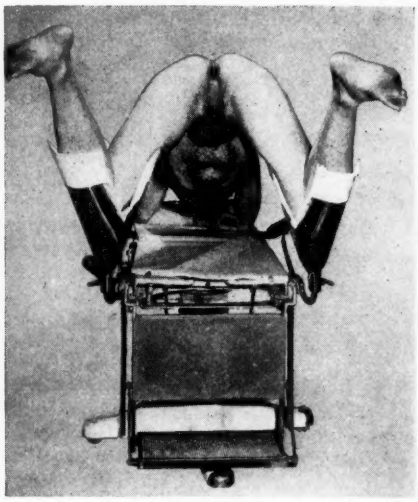

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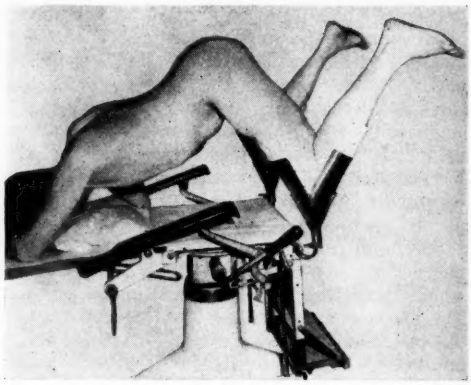

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period January 1, 1940 to December 31, 1948. A careful analysis of the material on the basis of stage of involvement, operability, and results obtained is presented. The results are also compared with those obtained in other clinics by surgical treatment and by surgical treatment combined with radiotherapy. The preponderant number of cases have been subjected to a systematic preoperative and postoperative radiotherapy.

Nielsen's discussion is based also on a large group of cases, "1,420 fresh cases comprising all cases of primary breast cancer referred to the Radium Centre during the period 1931–44, i.e. all the patients referred to us during the period except those with recurrences. All the patients were followed up through the entire observation period (none untraced)." (The latter statement must call attention to the admirable completeness of this study from the standpoint of the results obtained.)

These cases were treated by combined preoperative and postoperative radio therapy and surgical excision. In the period from 1931 to 1938 preoperative radiation therapy was "in moderate doses." In 1938 it was changed to "considerably higher doses" which have been employed ever since. In cases in which preoperative therapy was given at the Radium Centre the surgical treatment was carried out by one surgeon—O. Chievitz.

The cases referred to the Radium Centre fall largely into three groups: 510 "fresh" cases referred directly to the Centre and treated by preoperative and postoperative radiation therapy combined with surgery; 358 cases operated upon elsewhere and referred for postoperative therapy; and 306 unoperable cases. The results in the entire group are carefully tabulated and analyzed, and compared with the results expected from other clinics.

Altogether these three papers form a comprehensive and valuable contribution to the important subject of carcinoma of the breast. Many facets of the subject—the treatment of inoperable cases, the value of hormone therapy, the importance of centralization of cases to make possible more uniform management and comparable statistical records, changing attitudes toward radiation therapy—in addition to those which have been mentioned are thoughtfully discussed and add to the completeness and value of the symposium. SUMNER L. KOCH.

THE monograph *Neurosurgery; an Historical Sketch*[1] is, as its name implies, a very concise résumé of the development of neurosurgery as it is known today. Horrax briefly outlines the surgery of the head as practiced in prehistoric times up to the modern era. There are interesting plates which illustrate various types of craniectomies and trephine openings in skulls. Some of these skulls of prehistoric times show larger craniotomy openings than are occasionally employed today. The Edwin Smith papyrus is quoted to give an interesting ancient Egyptian classification of injuries: "(1) an ailment which I will treat, (2) an ailment with which I will contend, and (3) an ailment not to be treated."

The latter half of the book is devoted to the era of neurosurgery as a specialty. Historically, this begins at about 1890. Sir Victor Horsley is named the Father of Neurological Surgery, and it is proper that this book is dedicated to the memory of Sir Victor Horsley and Harvey Cushing. In a chronological manner the author develops the history of surgical procedures, the technical methods of surgical procedures including such details as position and the use of many of the tools we now take for granted. The use of anesthetics, drugs, and diagnostic aids is also discussed. All types of surgery of the nervous system are dealt with. There are photographs of major contributors to recent neurosurgical advancement as well as illustrations of some of the tools used in diagnosis and treatment of neurosurgical lesions.

This is the most concise treatise on the development of neurological surgery which has appeared. The important advances have been carefully described. The author is well qualified to recite the technical advances of neurological surgery because most of them have occurred in his lifetime, and he has had actual contact with many of them both in the days of his neurosurgical training and in his neurosurgical practice. DANIEL RUGE.

IN the preface to *The Principles and Methods of Physical Diagnosis*[1] by Simon S. Leopold, it is stated that the fundamental fault with most available textbooks of physical diagnosis is the fact that they devote too little attention to the underlying principles, the physics of examination, and too much space to attenuated and emasculated descriptions of clinical disease entities.

There are twenty chapters, all well written and all generously illustrated with good, well chosen and wisely placed photographs, some in color, diagrams and line drawings. The chapters are uniformly good so that it is difficult to pick out any unusual ones, though chapter 4 on the examination of the musculoskeletal system is excellent, as is chapter 6, "The Sounds from the Thorax: Acoustic Principles," which was written by S. Reed Warren, Jr. The chapter on history taking is reserved for the last and very wisely so. From the time the new student is in the last portion of his first year he has been told the importance of taking a complete, careful and accurate history. But he has not been told how to take it nor is he capable of taking it at this time because he has not yet learned the symptoms of disease and does not have at his command sufficient knowledge of anatomy, physiology, and pathology to even ask intelligent questions, let alone interpret the answers.

This book is recommended to the student, for in it he will find that taking a history and examining a pa-

[1]NEUROSURGERY; AN HISTORICAL SKETCH. By Gilbert Horrax, M.D., Sc.D. Springfield, Ill.: Charles C Thomas, 1952.

[1]THE PRINCIPLES AND METHODS OF PHYSICAL DIAGNOSIS; CORRELATION OF PHYSICAL SIGNS WITH PHYSIOLOGIC AND PATHOLOGIC CHANGES IN DISEASE. By Simon S. Leopold, M.D. Philadelphia, London: W. B. Saunders Co., 1952.

tient becomes a stimulating, fast, orderly, intriguing adventure instead of a monotonous, tedious routine. The teacher will find in it a way of appraising his own methods and assistance in covering this field. We are currently making every effort to reduce the cost of medical care and one of the best ways to do this is to take a thorough history and make a complete medical examination, thereby eliminating laboratory procedures except those absolutely essential for the pin-pointing of facts. Certain clinical laboratory procedures are often essential, but they should not be ordered in a shotgun fashion nor are they routinely necessary. Careful examination will often eliminate the necessity for many of these routine procedures. In the chapter on the examination of the chest there is a quotation attributed to Waring which states that the roentgen ray should be used not merely for diagnosis but as a teacher of physical diagnosis. With rare exceptions, none of the diagnostic tools available to us is capable of making a clinical diagnosis. In the last analysis, the diagnosis must come from the interpretation that the examiner places on all of his findings. Even in those instances in which diagnostic procedure does make a definite diagnosis, it in no way guarantees to tell the whole story nor does it indicate any other condition that might be present at the same time.

With this thought in mind, this book has much to offer to the general practitioner or specialist in any branch of medicine. RUSSELL T. BOTHE.

IN *Roentgenology in Obstetrics and Gynecology*[1] William Snow presents his original observations and personal experiences in the roentgen study of over 12,000 pregnancies. The relative merits of the various techniques for roentgen pelvimetry are undoubtedly material for valid argument. Doctor Snow's method has the advantage of simplicity. It is easily understood and easily applied. It requires no special apparatus except distorted rulers. His method compensates for roentgen ray divergence by using distorted rulers for measuring distances on the image. Directions are clearly stated for its application.

The text gives a general review of roentgenology applied to obstetrics and gynecology. It will be of particular interest to those who wish to familiarize themselves with Snow's technique of roentgen pelvimetry. Exception may, perhaps, be taken to some of the author's opinions concerning clinical applications of pelvic roentgenometry. It is an invaluable instrument which gives the obstetrician an excellent idea of the one thing which can be judged with considerable accuracy, namely, the size and shape of the pelvis. It does not, however, replace his clinical judgment nor does it supply him with information relative to other equally important and vital factors influencing the outcome of labor.

The familiar gynecoid and android groups are retained in the classification of pelvic types used in the text, but anthropoid and platypelloid pelves are included in the gynecoid group. Pelves which are not typically gynecoid or typically android are classified as mixed types. Geometric terms are used in describing the architecture of the pelvis. Each pelvic portion is considered individually. It is of interest to note that the possible significance of the posterior sagittal diameters of the inlet and midplane is not stressed. The importance of the configuration of the ischial spines, the sacrosciatic notch and the splay of the side walls is appropriately emphasized. Although computed capacities of the different planes are not discussed, the sums of the anterior-posterior and transverse diameters of the inlet and the midpelvis are given the clinician. A considerable portion of the text discusses roentgen studies of normal and abnormal presentations and positions prior to and during labor, roentgen study of the fetus, the soft parts and their abnormalities. As the author states, it is not possible to make brilliantly contrasting illustrations from low contrast roentgenograms. Tracings have been used, therefore, to supplement many of them.

The final chapters take up uterosalpingography, the roentgen study of the gastrointestinal and urinary tracts as related to the female genitals, and the recovery of tissue from x-radiation.

JOHN W. HUFFMAN.

THE monograph of 284 pages, *The Treatment of Injuries to the Nervous System*,[1] embraces the vast experience of the author over a number of years. From knowledge attained as a neurosurgeon at Boston City Hospital the author has presented the methods of treatment which he has found to have proved worth while. His concepts, of necessity in a book of this length, are somewhat didactic and categoric, inasmuch as his purpose is to present not a comprehensive review of the subject of trauma to the nervous system but rather his own opinions on the subject.

The opening paragraphs deal with certain problems common to all injuries to the central nervous system, such as "on the spot" treatment, transportation, care of open wounds, administration of drugs, and the priority given to the treatment of such complications as a ruptured viscus and certain thoracic wounds. A consideration of the altered physiology and the pathologic factors which obtain to produce alteration of intracranial pressure is presented in lucid manner. The pathogenesis and the importance of herniation of a portion of the medial aspect of the temporal lobe through the tentorium are stressed. The recognition of this emergency and the method of its alleviation, namely incision and section of the tentorial incisura, are presented.

The author then describes the treatment of head injuries, both nonoperable and operable. One of the newer therapeutic methods included is the injection

[1] ROENTGENOLOGY IN OBSTETRICS AND GYNECOLOGY. By William Snow, M.D. 2nd enl. ed. Springfield, Ill.: Charles C Thomas, 1952.

[1] THE TREATMENT OF INJURIES TO THE NERVOUS SYSTEM. By Donald Munro, M.D., F.A.C.S. Philadelphia, London: W. B. Saunders Co., 1952.

of Ringer's solution into the lumbar subarachnoid space in those instances in which the compressed brain does not expand after removal of a subdural hematoma.

In the section that pertains to treatment of injuries to the spinal cord and cauda equina, the problem of handling these patients is considered from the standpoints of diagnosis, the treatment of surgical and spinal shock, reparative surgical procedures, rhizotomy for spasms, physiotherapy, and the various stages of amputation. The braces and splints employed in ambulation are detailed.

The author's method of treatment of vesical dysfunction after injury to the spinal cord is well described. The physiology of normal micturition is reviewed. A rather complete consideration of the use of tidal drainage and cystometric determinations and the interpretation of cystometrograms is followed by a classification of neurogenic vesical dysfunction. The use of tidal drainage in therapy is then presented. Other methods in use for alleviation of vesical dysfunction are rather summarily passed over.

The book also has chapters devoted to the treatment of injuries to the cranial nerves, spinal roots, peripheral nerves and autonomic nervous system. A chapter that should prove extremely valuable to the general surgeon describes technique employed and equipment used for emergency and other relevant surgical procedures. The concluding chapters consider the problems of the cost of medical care, paraplegics, the responsibility of the hospital trustees and staff, and some general aspects of rehabilitation.

This volume will be useful to a rather wide group of physicians, including general practitioners, general surgeons, urologists, physiotherapists, and neurosurgeons. It is recommended for both medical libraries and personal collections. HENDRIK J. SVIEN.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE CYCLOPEDIA OF MEDICINE, SURGERY, SPECIALTIES. Editor-in-Chief, George Morris Piersol, M.D. Assistant Editor, Edward L. Bortz, M.D. 14 vols., 3rd ed. Philadelphia: F. A. Davis Co., 1952.

ESSENTIALS OF SURGERY FOR DENTAL STUDENTS. By J. Cosbie Ross, M.B. (Hon.), Ch.M. (Liverpool), F.R.C.S. (England). 2nd ed. Edinburgh, London: E. & S. Livingstone Ltd.; Baltimore: The Williams & Wilkins Co., 1952.

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CONGENITAL ANOMALIES OF THE HEART AND GREAT VESSELS. By Maurice A. Schnitker, B.S., M.D., F.A.C.P. New York: Oxford University Press, 1952.

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THE PHARMACOLOGY OF ANESTHETIC DRUGS; A SYLLABUS FOR STUDENTS AND CLINICIANS. By John Adriani, M.D. 3rd rev. ed. Springfield, Ill.: Charles C Thomas, 1952.

MEDICAL DEPARTMENT, UNITED STATES ARMY, SURGERY IN WORLD WAR II. THE PHYSIOLOGIC EFFECTS OF WOUNDS. By The Board for the Study of the Severely Wounded, North African-Mediterranean Theater of Operations. Washington: Office of the Surgeon General, Department of the Army, 1952.

SINDROMI DOLOROSE DOPO INTERVENTI GASTRICI E LORO TERAPIA CHIRURGICA. By Luigi Leopoldo Bracco. Torino: Edizioni Minerva Medica, 1952.

SURGERY FOR NURSES. By James Moroney, M.B., Ch.B., F.R.C.S. (Eng.), L.R.C.P. (Lond.). With a foreword by Miss Dorothy M. Smith, O.B.E. 2nd ed. Edinburgh, London: E. & S. Livingstone Ltd.; Baltimore: The Williams & Wilkins Co., 1952.

TEXTBOOK OF SURGERY. Edited by H. F. Moseley, M.A., D.M., M.Ch. (Oxon.), F.A.C.S., F.R.C.S. (Eng.), F.R.C.S. (C). With a foreword by G. Gavin Miller, M.D., C.M., M.Sc., F.R.C.S. (C), F.A.C.S. St. Louis: The C. V. Mosby Co., 1952.

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DERMATOLOGY; ESSENTIALS OF DIAGNOSIS AND TREATMENT. By Marion B. Sulzberger, M.D., and Jack Wolf, M.D. Chicago, Ill.: The Year Book Publishers, Inc., 1952.

ESSENTIALS OF INFANT FEEDING FOR PHYSICIANS; A PRACTICAL TEXT FOR RAPID REFERENCE. By Herman Frederic Meyer, A.B., M.D. Springfield, Ill.: Charles C Thomas, 1952.